

SECTION 7

PLAN FORMULATION AND EVALUATION

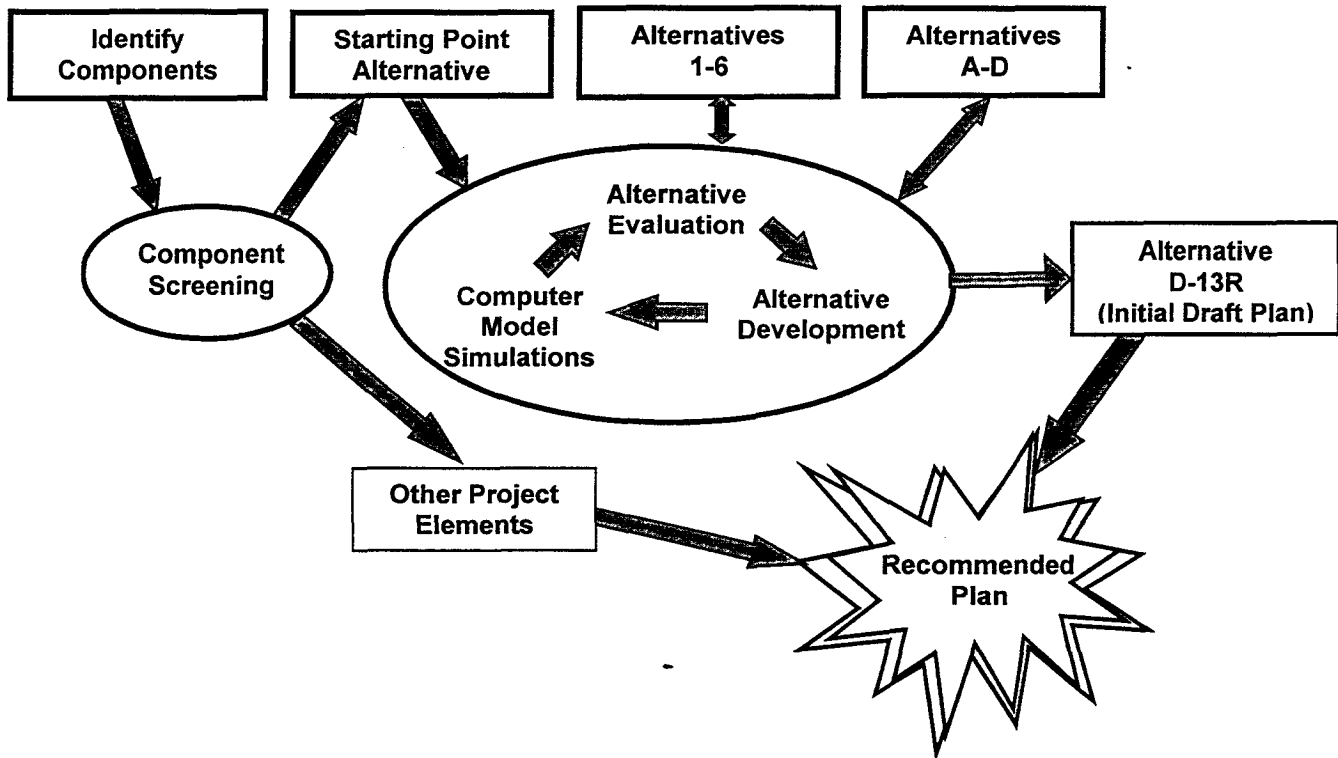
The purpose of this Section is to explain the process, called plan formulation, used in the Restudy to develop and evaluate alternative plans. This process involved the development of potential solutions to the water resource problems and the evaluations used to select the Comprehensive Plan. The iterative planning process followed during the Restudy is fully presented in this Section. In being so transparent and thorough, this Section presents information about planning iterations that is not typically found in a Corps feasibility report. While the process of following several progressive and comparative iterations is not unusual in water resources planning, it may be unusual to find it so rigorously documented. It would be more likely to find a simple presentation of the final array of alternatives (see *Section 7.5*), with only a brief overview of the iterations that led to that array. In presenting all of the iterations, the Restudy has fully disclosed the decision making process that led to the recommended plan. Such full disclosure may carry the price of some confusion when it so clearly shows that the basis for making decisions continue to change with each iteration.

7.1 PLAN FORMULATION AND EVALUATION METHODOLOGY

Plan formulation is a repetitive, or iterative, process of identifying alternative plans that achieve a set of planning objectives and allows those plans to be modified as more information becomes available. Each subsequent iteration of this process provides an opportunity to refine and sharpen the planning focus. Key steps in formulating the alternative plans are shown in *Figure 7-1*.

This plan formulation process evolved over three years, ultimately resulting in selection of a recommended plan. During this time frame, the Restudy team used an iterative process to identify and evaluate the merits of individual components and the effect of combining these components into "comprehensive plans." This process involved separate sequential steps that allowed plans to be modified, as more information became available, allowing the opportunity to refine and sharpen the planning focus. This process resulted in discreet steps of formulation results that are displayed, as such, in this section. These discreet plan formulation steps are displayed in *Table 7-1*.

**FIGURE 7-1
ALTERNATIVE PLAN
FORMULATION & EVALUATION PROCESS**



**TABLE 7-1
PLAN FORMULATION STEPS**

Formulation Process (Steps)	→	Resulting Recommendation
Component Screening		Formulation of Alternatives 1-6
Alternatives 1-6		Additional Formulation of Alternatives 3-6 (A-D)
Alternatives A-D		Further formulation of Alternative D
Alternative D-13R		Selected as Initial Draft Plan
Other Project Elements (Separable Elements)		Added to Initial Draft Plan to form Recommended Plan

7.2 IDENTIFICATION AND SCREENING OF PLAN COMPONENTS

Plan formulation began by developing a list of the many different ideas to achieve the planning goals and objectives. These different ideas are called "components". Components are the individual building blocks that can be combined in various ways to form alternative plans. They include both structural measures, such as reservoirs, pump stations, and canals, and nonstructural measures, such as reservoir operating schedules.

7.2.1 Identification of Plan Components

The Restudy was not the first effort to develop a list of components for water management in south Florida. Rather, it was able to take advantage of a vast array of previous studies and plans with similar planning goals and objectives. The Restudy's first list of components was developed in January 1996 and included components identified in the Reconnaissance Study (U.S. Army Corps of Engineers, 1994), the South Florida Water Management District's Draft Lower East Coast Regional Water Supply Plan (SFWMD, 1994a), and other sources. These sources were reviewed and discussed by the Restudy Team, and a first group of components were subsequently listed, described and linked to the planning goals and objectives.

This first list of components was considered and refined by the Governor's Commission for a Sustainable South Florida in its development of the *Conceptual Plan for the Restudy* (GCSSF, 1996b). The Conceptual Plan contained 40 components ("preferred options"), assembled into 13 thematic concepts, and served as the Restudy's initial framework for organizing components and developing a Comprehensive Plan (see *Section 6* of this report).

The Restudy Team met again in November 1996 to design a formulation and evaluation strategy for developing comprehensive plans. This meeting resulted in the development of the document entitled *Restudy Plan Formulation* (see *Appendix A* of this report) which outlined the Restudy goals and objectives, and listed and briefly described the components to be considered in developing alternative comprehensive plans.

The *Restudy Plan Formulation* document was subsequently used at 20 stakeholder focus group meetings throughout south Florida between January 1997 and May 1997 (see *Section 11* of this report). These meetings helped to ensure that most stakeholders were satisfied with the range of components to be considered and the strategy for formulating and evaluating alternative plans.

7.2.2 Screening of Plan Components

By the end of 1996, these efforts had produced an extensive inventory of potential components. Even after an initial screening of these ideas, the list of components numbered 112 (see *Appendix A, Section 1* of this report). The approach adopted by the Restudy Team to use these components in formulating a Comprehensive Plan was to begin with the formulation of a single plan. This plan, which the Restudy Team called the "Starting Point", would combine many of the listed components and could progressively be refined and shaped into the best possible Comprehensive Plan. In order to determine which components to include in

the Starting Point plan, as well as in subsequent refinements, the list of components were evaluated to:

- (1) optimize the general size, location, and configuration of certain components based on hydrologic criteria;
- (2) rank order similar components in terms of their dollar costs and the magnitude of their non-dollar outputs; and
- (3) reduce the number of components to a more manageable number for consideration in subsequent steps.

This evaluation process was called screening, and involved developing information bases from the Lower East Coast Regional Water Supply planning process and the Water Preserve Areas Land Suitability Analysis; hydrologic modeling primarily using the Everglades Screening Model; and a cost effectiveness analysis. The conclusions of the screening analysis are in *Appendix A, Section 1* of this report.

7.2.2.1 Screening Using the Lower East Coast Regional Water Supply Planning Process

The South Florida Water Management District's Lower East Coast Regional Water Supply planning process modeled and evaluated a series of five alternatives. Of the 112 Restudy components, 35 were previously modeled and evaluated in the Lower East Coast Regional Water Supply planning process.

Preliminary results from these alternatives provided information about the relative storage capabilities of components. In addition, it also provided insight into the system-wide affects and interactions among components. For example, the plan revealed the combined effects of modifications of the Lake Okeechobee operation schedule and storage facilities outside the Lake. This information was useful in establishing the best range of storage volumes. In addition, the benefits of rainfall driven delivery schedules for the Everglades were also evaluated.

7.2.2.2 Screening Using the Water Preserve Areas Land Suitability Analysis

The Water Preserve Areas concept was initially proposed by the National Audubon Society (1994) as a way to capture and store excess surface waters that are normally discharged into the coastal waters through the C&SF Project canals. This area would also serve as a buffer between the Everglades and the urban areas to the east. This concept has evolved from a number of studies including the South Florida Water Management District's East Coast Buffer Feasibility Study (CH2M-Hill, 1994) as part of the Lower East Coast Regional Water Supply planning process.

In 1995, a feasibility study for the Water Preserve Areas was initiated by the Corps and the South Florida Water Management District to accelerate the formulation and evaluation of Water Preserve Areas components. This study's land suitability analysis provided information about land cover, hydroperiod regime, and soils that was useful in determining the best places to: (1) store water, (2) recharge the aquifer, and (3) restore degraded wetlands.

This information provided considerable insight to determine the best locations for the Water Preserve Areas components. For example, the land suitability analysis identified sensitive wetlands that should be restored and less sensitive wetlands that could be used for water management purposes.

7.2.2.3 Screening Using the Hydrologic Screening Models

The Everglades Screening Model was the primary hydrologic computer model used for screening. This model simulates how water moves through south Florida and how operational and structural modifications to the C&SF Project may affect water movement. A complete discussion of the hydrologic modeling is in *Appendix B*.

The Everglades Screening model was used to quickly evaluate and narrow the range of water storage concepts in the Everglades Agricultural Area, the Kissimmee River Basin, the Caloosahatchee Basin, and the St. Lucie Basin. It was also used to identify the range of storage options for: alternative Lake Okeechobee operation schedules; Lake Okeechobee aquifer storage and recovery systems; and Water Preserve Areas reservoirs and wetlands. It also provided information about how much water could be retained in the Water Conservation Areas using seepage barrier components.

7.2.2.4 Screening Using Cost Effectiveness Analysis

Cost effectiveness analysis was used to help identify the least expensive options to achieve a desired effect. Cost effectiveness analysis is typically done near the end of a study to compare complete alternative plans. However, the analysis can also be used earlier to compare similar components to assist in the formulation of cost effective alternative plans. A summary of how the analysis was used in the Restudy Plan Formulation is included in *Appendix A, Section 2* of this report.

Of the 112 Restudy components, 47 were analyzed using the cost effectiveness analysis. These components were grouped into seven different functional categories of output including, for example: reducing phosphorus loading to Lake Okeechobee, increasing water storage capacity in the Lower East Coast, and increasing acres of wetlands throughout the study area.

The cost effectiveness analysis provided information about the least costly way to achieve each level of output. For example, the analysis revealed that storage reservoirs in the Caloosahatchee Basin were more cost effective than Aquifer Storage and Recovery around Lake Okeechobee. Therefore, the reservoirs would be a better initial financial investment. This type of information was useful in selecting the best size of a component as well as a priority for selecting components based on the cost for the level of output achieved. However, the analysis was limited in scope such that only a single output was measured for each component. For example, a storage reservoir in the St. Lucie Basin not only increases water supply but it also reduces damaging flows to the St. Lucie Estuary. In this case, the one-dimensional approach used for the analysis resulted in under-estimating the effectiveness of the component. However, in other cases there were negative effects that were not measured. For example, backpumping to Lake Okeechobee results in increased water supplies but it could impact the Lake's littoral zone and this impact was not measured during this analysis.

Further, without a target, the screening conclusion was limited to identification of the most efficient component. That is, the component with the lowest cost per unit of output desired. If an output target was available, and the most efficient component failed to meet its target, the analysis was used to identify the next most efficient component or group of components.

7.2.2.5 Screening Using Other Analyses and Best Professional Judgement

In addition to the other screening techniques, the Restudy Team used information from a variety of sources including previous C&SF Project studies, and South Florida Water Management District Surface Water Improvement and Management (SWIM) Plans. The Restudy Team also took advantage of the extensive knowledge and experience of the team members and others that have lived and worked in south Florida and had a day-to-day familiarity with the water resources issues being addressed in this feasibility study.

7.2.3 Screening Conclusions

A summary of the major findings from the screening analysis is shown in *Table 7-2*. For more detailed screening conclusions about each of the 112 components, see *Table 5* in *Appendix A, Section 1*.

**TABLE 7-2
SCREENING CONCLUSIONS SUMMARY**

KISSIMMEE RIVER REGION
• Storage reservoirs effective for Lake level management
• Water quality treatment very cost effective for improving Lake Okeechobee
• Paradise Run most cost effective way to increase spatial extent of wetlands in this basin
UPPER EAST COAST REGION
• Storage reservoirs for C-44 Basin effective to improve estuary conditions
• Increased backpumping of treated water to Lake Okeechobee cost effective; however, adverse impacts to Lake's littoral zone were not evaluated
• Adding Aquifer Storage & Recovery to storage reservoirs should be considered
• Opportunities to increase spatial extent of wetlands in this basin
• C-23, C-24, and C-25 Basins being considered in detail as part of Indian River Lagoon Study
CALOOSAHATCHEE RIVER REGION
• Storage reservoirs effective.
• Lake Hicpochee should be considered as first increment for storage
• Increased backpumping of treated water to Lake Okeechobee cost effective; however, adverse impacts to Lake's littoral zone were not evaluated
• Adding Aquifer Storage & Recovery to storage reservoirs should be considered
LAKE OKEECHOBEE REGION
• Increases to Lake levels cost effective; however, adverse impacts to Lake's littoral zone were not evaluated
• Regional Aquifer Storage & Recovery not cost effective in this area for Lake level management (however, later screening analyses showed that this component was effective at reducing flows to the St. Lucie and Caloosahatchee Estuaries)
EVERGLADES AGRICULTURAL AREA REGION
• Storage reservoirs effective
• Increased backpumping of treated water to Lake Okeechobee cost effective; however, potential adverse impacts to Lake's littoral zone were not evaluated
WATER CONSERVATION AREAS REGION
• Detailed modeling required to evaluate components to reconnect habitats
• Rainfall driven delivery schedules are needed to achieve hydropattern restoration
BIG CYPRESS REGION
• Restoration of southern Golden Gate Estates very cost effective to increase spatial extent of wetlands
LOWER EAST COAST REGION
• Southern L-8 project effective in delivering water to North Palm Beach County and Loxahatchee Slough
• Urban Water Supply: (depending on location) wellfield relocation/expansion, utility Aquifer Storage & Recovery, and secondary canal operations are effective
• Regional Aquifer Storage & Recovery is very effective on C-51 and Hillsboro Canals
• Opportunities to increase spatial extent of wetlands in Northern Palm Beach County, Model Lands, and Biscayne Bay coastal areas
WATER PRESERVE AREAS
• Storage reservoirs adjacent to Water Conservation Areas effective in a number of basins
• Aquifer Storage & Recovery should be considered to reduce size of storage reservoirs
• Seepage collection and backpumping generally most cost effective seepage management component
• Water quality treatment needed if drainage water is backpumped to natural areas
• Opportunities to increase spatial extent of wetlands

7.3 FORMULATION AND EVALUATION OF ALTERNATIVE PLANS

The next phase of plan formulation involved assembling components into alternative plans to meet the planning goals and objectives. These plans came from an iterative process that began with the formulation of a Starting Point plan based on the screening conclusions. Subsequent iterations methodically created new plans based on how well they performed relative to the objectives and associated performance measures and targets.

7.3.1 Methodology for Formulation and Evaluation of the Alternative Plans

Alternative plans were formulated and evaluated by two teams, the Alternative Development Team (ADT) and the Alternative Evaluation Team (AET). Each of these teams had a specific planning purpose. The Alternative Development Team was responsible for designing each alternative plan in response to the Alternative Evaluation Team's evaluations of the previous plan iteration. The designs of these alternative plans were built into the South Florida Water Management Model, a regional-scale hydrologic model (see *Appendix B* of this report), to identify plan effects. The Alternative Evaluation Team was responsible for evaluating each plan's strengths and weaknesses, and describing plan shortfalls to the Alternative Development Team. This repetitive formulation and evaluation process progressively refined and improved the performance of subsequent alternative plans.

Communication between these teams and among team members was facilitated by several mechanisms. First, a small cadre of interdisciplinary experts participated on both the Alternative Evaluation Team and the Alternative Development Team to assure timely and consistent communication between the teams. Second, the over 100 members of the overall Restudy Team met seven times during this process and had the opportunity to participate in both the formulation and evaluation processes.

Finally, because of the large and geographically dispersed number of people involved and interested in the Restudy, the Internet was used to communicate formulation and evaluation results. This allowed the Restudy Team to solicit comments from a broad base of the public and permitted people to participate as team decisions were being made. The Restudy Internet address is <http://www.restudy.org>.

7.3.1.1 Alternative Development Team

The Alternative Development Team was a multi-agency team of about 30 planners, engineers and scientists. The team identified and designed specific components to be simulated in the South Florida Water Management Model with

the intent to improve the performance of each alternative plan and to test different strategies for component modification identified by the Alternative Evaluation Team.

7.3.1.2 South Florida Water Management Model

The South Florida Water Management Model (see *Appendix B*) is a regional-scale computer model of the water resources system from Lake Okeechobee to Florida Bay. This is an integrated surface water – groundwater model based on historical climatic data for the 31-year period between 1965 and 1995. This period includes a range of drought and wet periods that are believed to encompass a number of extreme hydrologic events for simulation purposes.

The model simulates the major elements of the hydrologic cycle in south Florida including rainfall, evapotranspiration, infiltration, overland and groundwater flow, canal flow, canal-groundwater seepage, levee seepage and groundwater pumping. As the water management control structures and operational rules are changed, the model simulates the effects on these hydrologic conditions.

The model has been calibrated and verified using water level and discharge measurements at hundreds of locations distributed throughout the region. Technical experts have extensively reviewed and accepted this model as the best available tool for analyzing regional-scale structural and operational changes to the complex water management system in south Florida.

The model was used to estimate hydrologic responses to proposed structural and operational modifications to the water management system in south Florida. The large scale and spatial extent of the model allows it to perform system-wide evaluations. For example, the model can estimate hydrologic conditions, such as the depth of water, in the Water Conservation Areas and Everglades National Park, if changes are made in Lake Okeechobee's operations.

7.3.1.3 Alternative Evaluation Team

The Alternative Evaluation Team was also a multi-agency team of about 50 biological and physical resource specialists, planners, and engineers. The team was responsible for plan evaluation, including:

- (1) developing quantitative indicators of plans' performance (called performance measures) and targets for each indicator,
- (2) comparing model results against performance targets to identify the most significant strengths and shortfalls of each alternative plan,

- (3) providing the "top 10" shortfalls of each plan to the Alternative Development Team,
- (4) performing the evaluation and comparison of the final array of comprehensive alternative plans, and
- (5) collating and considering comments from the public and Restudy Team regarding each alternative plan.

The Alternative Evaluation Team used multiple analytical tools to accomplish the alternative plan evaluations: performance measures from the South Florida Water Management Model computer simulations, the Across-Trophic-Level System Simulation (ATLSS) model, and water quality models.

7.3.1.3.1 Performance Measures

The Alternative Evaluation Team developed a set of performance measures as the basis of its evaluations for all areas of concern. Each performance measure was implicitly linked to one or more of the planning objectives, and consisted of a measurable indicator and target. The performance measures were largely indicators of hydrologic characteristics. The performance measures were used to judge how well each alternative met the objectives.

Many of the performance measures used to measure progress toward the ecological objectives were based on hydrologic patterns revealed by the Natural System Model. This model was developed from the South Florida Water Management Model by removing the complex network of canals, structures and levees in the current system and replacing them with the pre-drainage rivers, creeks, and transverse glades. The topography of subsided areas are adjusted in the Natural System Model to estimated pre-drainage levels. The output from the Natural System Model represents the best available approximation of the pre-drainage condition and is the basis for many of the restoration targets. Refer to *Appendix B* of this report for a more detailed description of the Natural System Model.

The hydrologic patterns shown by the Natural System Model are generally consistent with what is known or hypothesized about the optimum hydrologic patterns for a number of characteristic plant and animal communities in the historic Everglades. The Alternative Evaluation Team agreed that it was appropriate to use the model as a basis for setting targets if appropriate scales were used. For example, it would be appropriate to use the model to get targets for the duration of inundation, depth and distribution patterns over a broad area; but it would not be appropriate for development of depth targets at scales less than plus/minus 0.5 feet, or to be used for estimates of flow volumes.

Performance measures were also developed to evaluate the degree to which the alternative plans are likely to meet water supply objectives. These considered the frequency, duration and severity of water supply restrictions for both urban and agricultural areas. Flood protection performance measures were also developed. However, due to the coarse spatial resolution of the South Florida Water Management Model, these performance measures were simply used to identify areas of concern.

For each alternative plan, the South Florida Water Management Model produced information about the performance measures in the form of tables, graphs and maps. This information was useful for two reasons. First, the results could be compared against the performance measure targets to evaluate plan success at achieving the objectives. Second, the information was used to compare different conditions including: the Existing Condition (1995 Base), the Future "Without Plan" Condition (2050 Base), and any of the previously simulated alternative plans. For example, a graph may compare Alternative 1 with the Natural System Model (Historic Condition), the Existing Condition, and the Future without Plan Condition.

7.3.1.3.2 Across Trophic Level System Simulation Model

The Across Trophic Level System Simulation (ATLSS) model (*Appendix D*) is a set of computer models that integrates several approaches for different levels of the ecologic hierarchy. The model uses hydrologic information from the South Florida Water Management Model simulations of the alternative plans and predicts biological responses of several species and species groups. The basic models of ATLSS model included:

- Cape Sable Seaside Sparrow Breeding Potential Index
- Wading Bird Foraging Condition Index
- White-tailed Deer Breeding Potential Index
- Landscape Fish Model
- Cape Sable Seaside Sparrow Individual Based Model
- Snail Kite Breeding Potential Index

The nature and extent of ATLSS model results depended on the progress of each model's development and therefore varied among species and species groups. For example, detailed results were available for the Cape Sable seaside sparrow's western population and for fish abundance because development of these models was nearly complete at the time the alternative plans were evaluated. Less detailed results were available for foraging and breeding condition indices for the snail kite, wading birds, and others because these models were in earlier stages of development.

ATLSS model results for each alternative were compared with results for other alternatives, the 2050 Base, and in most cases, with 1995 Base. When results indicated that an alternative would improve species' biological responses as compared to the other conditions, the Restudy Team concluded that there was evidence to suggest that the alternative was beneficial for those species as compared to the other conditions.

7.3.1.3.3 Water Quality Models

The effects of alternative plans on water quality were evaluated using three analytical tools. The Lake Okeechobee Water Quality Model (James *et al.*, 1997) simulated lake eutrophication processes. The Everglades Water Quality Model (SFWMD, 1997h) simulated phosphorus transport in the Everglades Protection Area. In addition to these two models, an analysis (Walker, 1998) of the performance of the Everglades Construction Project and proposed reservoirs in reducing phosphorus was utilized.

7.3.1.4 Basis for Formulation and Tradeoffs for the Alternative Plans

In formulation for ecological restoration, the team agreed that it was important to make progress toward all the targets and that achieving a target in one area should not cause damage to another area. Recovery of an Everglades-like system is more likely to occur through recovery of a strong balance of all of the hydrological features that characterized the pre-drainage system. These features include spatial extent, duration of hydroperiods, sheet flow, flow volumes into estuaries and depth patterns.

Fundamentally different strategies for achieving Everglades restoration have been characterized as the "cookie cutter" and "Xerox reduction" approaches. Should the goal be "point-for-point" matches with pre-drainage characteristics in the remaining portions of the Everglades ("cookie cutter"), or should the goal be to recreate all the original community and landscape proportions in an Everglades that is now one-half its pre-drainage size ("Xerox reduction")? While this question prompted a healthy debate, most recent views have been (a) we should do neither, or (b) we should do some combination of the two.

Plan formulation for the Restudy was based on a variety of approaches. Alternative plans were formulated in an attempt to achieve pre-drainage targets, that is, a "cookie cutter" approach was followed. Additionally, a "Xerox reduction" approach was also achieved because the proportion of long-hydroperiod sloughs to short-hydroperiod prairies in the current Everglades is similar to the proportion between these two landscapes in the pre-drainage system.

The Restudy Team began formulation with the expectation that it would be possible to design a plan that would meet all of the performance measure targets.

The team assumed that the targets could be met by increasing the amount of stored water, minimizing the amount of excess water to tide and re-distributing it.

As the process proceeded, it became increasingly apparent that, given the physical, operational, legal, and societal constraints in south Florida, it would not be possible to fully achieve every performance measure target. The constraints created situations where alternative plans could not meet all targets in all areas at all times resulting in the need to make tradeoffs among competing objectives. Tradeoff situations included cases where the volume of water was insufficient, or management options for local or sub-regional water supplies were sufficiently limited. Since it was not possible to reach all targets, the Restudy Team established the following guidelines for setting priorities among competing performance measure targets:

- (1) The pre-drainage hydrological patterns shown by the Natural System Model are most likely to lead to the recovery of natural systems, and should be a priority for the natural wetlands of south Florida over other targets.
- (2) Where not all pre-drainage hydrological parameters can be recovered, or where meeting these targets reduces the ability of a plan to meet pre-drainage targets in a different part of the system, the Conceptual Ecological Models (see *Section 5* of this report) set the priority for hydrological targets. Each Conceptual Ecological Model identifies critical ecological pathways which show the critical hydrological parameters related to ecological changes, and which should be given priority.
- (3) Restoration should not cause additional, long-term ecological damage. However, the Restudy Team, recognizing that substantial changes in community structure and natural system boundaries have occurred over the past 100 years, is willing to see additional local community shifts (short-term "damage") occur if these would allow the realization of larger scale restoration targets. This view is consistent with the recognition by most Everglades ecologists that a successful Everglades restoration program will be one that recovers those ecological characteristics that defined the original system to a sufficient degree so that a "new" Everglades-type ecosystem is created (Davis and Ogden, 1994).
- (4) Priorities for ecological targets may be based on criteria other than those shown by the pre-drainage model where there is a compelling technical basis for doing so. However, such targets may not have priority if, in meeting these targets, it becomes substantially more difficult to reach ecological targets in other regions.

7.3.2 Formulation and Evaluation Iterations

The formulation of alternative plans was generally an iterative process in which each plan was developed as a result of the evaluation of the previous alternative. Through the first three iterations, each alternative plan was developed in an attempt to improve upon the previous plan's performance. The iterative nature of this process allowed the team to learn more about particular components of the plans including how the components perform under a range of conditions. Through the last few alternative plans, a different approach to Everglades ecosystem restoration was explored, namely restoration through removal of the canals and levees within the remaining Everglades to restore connectivity and unrestricted sheetflow.

Each iteration began with an alternative plan. The components of that plan were built into the South Florida Water Management Model to simulate the plan's hydrologic effects. The model results were then posted on the Internet, and the Alternative Evaluation Team and others reviewed the results. These results were used as input into other models as described above to evaluate the plan's performance. Comments were provided to the Alternative Development Team, which in turn modified the alternative plan to improve performance shortfalls, thus creating the next alternative.

The iterative process to formulate and evaluate alternative plans began in September 1997 and was completed in June 1998.

7.3.2.1 Starting Point

The Starting Point was the first alternative plan formulated. It combined many of the features that were considered to solve system-wide problems. It was formulated by a Restudy sub-team with extensive experience in the C&SF Project and related studies such as the Lower East Coast Regional Water Supply Plan process and the Restudy Reconnaissance study.

The screening analysis provided the information needed to assemble the components into the Starting Point plan. Screening identified solutions for specific problems and the Starting Point integrated the individual solutions into a whole system-wide response. The components of the Starting Point are listed in *Table 7-3*. The general philosophy of the Starting Point, and the first few alternatives, was to start small and build components with the intent to provide a clear justification as to why additional components were added in subsequent iterations.

The evaluation of the Starting Point showed the need for increased water storage throughout the system to meet ecological restoration and water supply objectives. In addition, the Starting Point included extensive seepage control components to keep more water in the natural system. However, the reduced

seepage led to increased saltwater intrusion into the Biscayne Aquifer and urban wellfields. Therefore, formulation of Alternative 1 proceeded by increasing the storage capacity of the components proposed in the Starting Point and scaling back the rate of seepage management. It also included additional storage components and additional, more passive, seepage management components. The theme of adding additional storage continued throughout the plan formulation process.

**TABLE 7-3
MAJOR COMPONENTS OF THE
"STARTING POINT"**

EAA Storage Reservoir
Caloosahatchee/C-43 Basin Storage Reservoir
St. Lucie/C-44 Basin Storage Reservoir
North of Lake Okeechobee Storage Reservoir
Everglades Rainfall-Driven Operations
Water Preserve Areas Components:
Site 1 Impoundment
Water Conservation Area-2B Seepage Management
C-11 Impoundment
Western C-9 Recharge Area
Central Lakebelt In-Ground Storage Reservoir
Bird Drive Impoundment
L-31N Seepage Management

7.3.2.2 Alternatives 1-6

Alternative 1 was formulated to overcome the water storage shortfalls identified in the Starting Point plan and to reduce the negative impacts of aggressive seepage management. *Table 7-4* lists the major features and design criteria used in Alternative 1 as well as the Starting Point and Alternatives 2-6. The evaluations of Alternative 1 and subsequently Alternative 2 continued to show the need for improved seepage management and greater storage throughout the system. However, it became evident that the remaining options to store additional water in surface reservoirs were more costly and other non-traditional storage options, such as aquifer storage and recovery (ASR, see *Appendix C*), would have to be considered.

Alternative 3 substantially increased water storage capacity by including a series of aquifer storage and recovery components. However, the plan needed improvement in the timing and distribution of the water deliveries. Further, none of the plans had attempted to reestablish unrestricted sheetflow (connectivity) through the remaining Everglades.

Alternative 4 included partially decompartmentalizing the remaining natural system by removing physical barriers to flows. The alternative evolved from analyses of a series of South Florida Water Management Model computer simulations, called scenarios, that combined components of Alternative 3 with different amounts of levee and canal removal within the remaining Everglades. At a Restudy Team meeting on December 15, 1997 various approaches for modeling levee and canal removal within the natural areas of the Everglades were discussed.

Three scenarios were formulated as a result of that discussion. Each scenario progressively removed more of the internal compartments between the Water Conservation Areas. The Alternative Evaluation Team evaluation of these scenarios showed that as levee and canal removal increased from south to north flows to Shark River Slough increased and some benefit was seen in the southern portion of Water Conservation Area 3A where extreme high water was greatly reduced -- because of removal of the L-29. However, removal of the levees and canals also resulted in extreme high water conditions in Water Conservation Area 3B and eastern Water Conservation Area-3A. With complete removal of the levees and canals from within the Water Conservation Areas, high water in Water Conservation Area 3B was the most extreme of any scenario or alternative considered by the Restudy Team. Further, drying conditions in Loxahatchee National Wildlife Refuge (WCA 1), Water Conservation Area 2A, and Northeast Shark River Slough were exacerbated, increasing the burden on Lake Okeechobee and impacting the littoral zone. Lower East Coast Region's dependence on the Lake for water supply increased as well.

Because one of the basic tenets of the Restudy is to do no harm to one part of the natural system in order to restore another, the team recommended taking a more moderate approach to levee and canal removal, understanding that if ways to mitigate the problems could be found, levee and canal removal of the upper part of the system could be reexamined at a later date.

Therefore, for Alternative 4 and each subsequent alternative, the barriers in the northern part of the system were retained. Specifically, the barriers between Loxahatchee National Wildlife Refuge and Water Conservation Area-2A and between Water Conservation Area-2A and Water Conservation Area-3A were kept to prevent excessive dry-downs in the Refuge and Water Conservation Area-2A and to protect Lake Okeechobee's littoral zone. The barrier between Water Conservation Area-2A and Water Conservation Area-2B was retained to prevent the excessive depths in Water Conservation Area-2B seen in the more extensive levee and canal removal scenarios.

The resulting alternative, Alternative 4, removed levees and canals within Water Conservation Area 3 and eliminated barriers between this Water Conservation Area and Everglades National Park. However, this alternative still produced unintended adverse consequences to Lake Okeechobee, water supply, and parts of the Water Conservation Areas.

Alternative 5 attempted to address problems created in Alternative 4. Many areas were substantially improved, but at this point it was clear that it would not be possible to precisely meet all targets. In addition, the timing and distribution of water in the Water Conservation Areas remained problematic.

Another plan, Alternative 6, was formulated to address the continuing problems identified from Alternative 5. This plan added additional high cost features including wastewater reuse. However, this plan was not evaluated in the same manner as the previous plans because the team recognized that the plans were no longer comparable. The formulation of the previous alternatives allowed the team to learn more about the individual plan components with each iteration. This led to component modifications and improvements in the later alternatives that were not included in the earlier alternatives. For example: excess flows in the Caloosahatchee Basin were identified and, as such, were available to store in the Caloosahatchee Basin or to backpump to Lake Okeechobee; and Biscayne Bay water demands were identified, resulting in degradation to the ecology of the Bay. Further, engineering designs of the components were improved upon with each iteration. For example, a stormwater treatment area was reduced in size from earlier plans because the land initially assumed to be available was not. An unintended consequence of these modifications and improvements was that the alternatives could not be fairly compared to each other. Therefore, the team decided to reformulate and redesign the alternative plans to place them on an equal footing for comparison.

**TABLE 7-4
MAJOR FEATURES OF STARTING POINT – ALTERNATIVE 6**

Major Features	Alternatives						
	Starting Point	1	2	3	4	5	6
North L.O. Storage	100K ac-ft	200K ac-ft	200K ac-ft	200K ac-ft	200K ac-ft	200K ac-ft	200K ac-ft
C-44 Basin Storage	20K ac-ft	20K ac-ft	40K ac-ft	40K ac-ft	40K ac-ft	40K ac-ft	40K ac-ft
C-43 Basin Storage	80K ac-ft	160K ac-ft	160K ac-ft 220 mgd ASR	160K ac-ft 220 mgd ASR	160K ac-ft 220 mgd ASR	160K ac-ft 220 mgd ASR	160K ac-ft 220 mgd ASR
EAA Storage Area	240K ac-ft	240K ac-ft	240K ac-ft	360K ac-ft	360K ac-ft	360K ac-ft	360K ac-ft
Additional L-8 Improvements					25 mgd ASR	25 mgd ASR	50 mgd ASR 48K ac-ft
Site 1 Impoundment	10K ac-ft	10K ac-ft	10K ac-ft	10K ac-ft 25 mgd ASR	10K ac-ft 75 mgd ASR	10K ac-ft 75 mgd ASR	14.8K ac-ft 150 mgd ASR
Western C-11 & North New River Diversion	6.4K ac-ft	6.4K ac-ft	6.4K ac-ft	6.4K ac-ft	6.4K ac-ft	6.4K ac-ft	6.4K ac-ft
C-9 Impoundment and Diversion	10K ac-ft	10K ac-ft	10K ac-ft	10K ac-ft	10K ac-ft	10K ac-ft	10K ac-ft
Central Lake Belt Storage	80K ac-ft	80K ac-ft	80K ac-ft	100K ac-ft	135.2K ac-ft	135.2K ac-ft	187.2K ac-ft
Bird Drive Basin Impoundment	11.5K ac-ft	11.5K ac-ft	11.5K ac-ft	11.5K ac-ft	11.5K ac-ft	11.5K ac-ft	11.5K ac-ft
L-31N Seepage Management	100% Levee 100% Groundwater	100% Levee	100% Levee 100% Wet Season Groundwater	100% Levee 100% Wet Season Groundwater	100% Levee 100% Wet Season Groundwater	100% Levee 100% Wet Season Groundwater	100% Levee 100% Wet Season Groundwater
Taylor Creek/Nubbin Slough Storage and Treatment			50K ac-ft Reservoir 20K ac-ft STA	50K ac-ft Reservoir 20K ac-ft STA	50K ac-ft Reservoir 20K ac-ft STA	50K ac-ft Reservoir 20K ac-ft STA	50K ac-ft Reservoir 20K ac-ft STA
Lake Okeechobee ASR				1K mgd ASR	1K mgd ASR	1K mgd ASR	1K mgd ASR
C-51 Regional Ground Water ASR				340 mgd ASR	540 mgd ASR	540 mgd ASR	340 mgd ASR
C-23/24/Northfork and Southfork Storage Reservoirs					165K ac-ft	190K ac-ft	192K ac-ft
North New River Regional Ground Water ASR				250 mgd ASR			
Hillsboro Canal Basin Regional Groundwater ASR				370 mgd ASR	220 mgd ASR	220 mgd ASR	
WCA-3 and ENP (Remove Canals and Levees)				9 miles of Canal	146 mi of Canal 82 mi of Levee	127 mi of Canal 54 mi of Levee	127 mi of Canal 56 mi of Levee
Palm Beach County Agriculture Reserve Reservoir					10K ac-ft	10K ac-ft 75 mgd ASR	19.9K ac-ft 75 mgd ASR
North Lake Belt Storage					70K ac-ft	70K ac-ft	90K ac-ft
Lower East Coast Water Conservation						6% Reduction in 2050 Utility Demands	6% Reduction in 2050 Utility Demands
South Dade County Reuse						131 mgd Capacity	131 mgd Capacity
C-51/Southern L-8 Reservoir							120K ac-ft Capacity
West Dade Reuse							100 mgd Capacity

Ac-ft - Acre-Feet, K- unit of 1,000's, STA - Stormwater Treatment Area, mi - miles, mgd - million Gallons per Day

7.3.2.3 Alternatives A-D

The next phase of plan formulation focused on developing a comparable array of alternative comprehensive plans. The team recognized that neither the Starting Point nor Alternatives 1 or 2 would achieve the planning objectives at levels that would be acceptable. Alternative 3, which had evolved from these first three plans, was clearly superior to its predecessors. Therefore, the Starting Point and Alternatives 1 and 2 were not considered further.

Next, the remaining alternatives were modified to reflect more current design assumptions that would make them comparable, and improve their performance. These changes fell into the following categories:

- (1) Operational changes that would allow better performance of the alternatives (for example, climate forecasting for Lake Okeechobee operations and related reservoirs) or operational changes required due to a change to another component.
- (2) Changes to the South Florida Water Management Model input data to account for better information (for example, runoff estimates from basins contributing inflow to the St. Lucie Estuary).
- (3) Modifications to correct design deficiencies identified during formulation of Alternatives 1-5 (for example, canal design and location for backpumping water from C-17 to the West Palm Beach Water Catchment Area) or; design modifications to improve performance without an increase in cost (for example, relocating aquifer storage and recovery facilities from Hillsboro Canal to Site 1 Reservoir).
- (4) Exclusion of components that were consistently poor performers (for example, North New River Regional Groundwater Aquifer Storage and Recovery).
- (5) Inclusion of components that proved to be extremely good performers, but were omitted from earlier alternatives due to insufficient data (for example, Caloosahatchee Backpumping to Lake Okeechobee).
- (6) Inclusion or exclusion of components as a result of changes to the base conditions (for example, inclusion of the C-4 Divide Structure that was previously believed to be implemented by the non-Federal sponsor but was subsequently proposed as an element of the Critical Projects Program).

In view of these changes, the team elected to rename the reformulated and redesigned alternative plans to clearly differentiate them from their earlier iterations. The final array of plans included:

- Alternative A, which was a reformulated and redesigned Alternative 3.
- Alternative B, which was a reformulated and redesigned Alternative 4.
- Alternative C, which was a reformulated and redesigned Alternative 5.
- Alternative D, which was Alternative 6.

Alternative A had the greatest number of changes from its original form, followed by Alternative B then C. *Tables 7-5 and 7-6* list the components in each alternative. Further, *Figures 7-2, 7-3, 7-4, and 7-5* display select features of Alternatives A – D, respectively. For a more complete description of the components included in Alternatives A – D, see *Appendix A, Section 3*.

The reformulation provided an opportunity to make other modifications in the modeling including using the most recent version of the Natural Systems Model (NSM v4.5). Previous alternatives (Starting Point – Alternative 5) had been evaluated and compared to a provisional version of this model. This newer version of the Natural System Model became available in December 1997, so the team agreed to use this newer version for the evaluation of Alternatives A through D.

With the reformulation of the alternative plans, the final set of Alternatives A through D underwent a rigorous evaluation using a variety of analytical tools and processes. These included: River of Grass Evaluation Methodology, Summary Evaluation Criteria, Keystone and Endangered Species analysis, and Water Quality analysis. The results of these analyses were arrayed and compared to identify significant differences among plans.

**TABLE 7-5
COMPONENTS COMMON TO ALTERNATIVES A – D**

Component Title		Alternatives			
		A (Alt 3 Rev)	B (Alt 4 Rev)	C (Alt 5 Rev)	D (Alt 6)
A	North L.O. Storage	✓	✓	✓	✓
B	C-44 Basin Storage	✓	✓	✓	✓
C	Environmental Water Supplies to St. Lucie Estuary	✓	✓	✓	✓
D	C-43 Basin Storage	✓	✓	✓	✓
E	Environmental Water Supplies to Caloosahatchee Estuary	✓	✓	✓	✓
F	Lake Okeechobee Regulation Schedule	✓	✓	✓	✓
G	EAA Storage Area	✓	✓	✓	✓
H	Everglades Rain-Driven Operations	✓	✓	✓	✓
K	Additional L-8 Improvements	✓	✓	✓	✓
L	Relocate Wellfield Operations	✓	✓	✓	✓
M	Site 1 Impoundment	✓	✓	✓	✓
O	Water Conservation Area 3A and 3B Levee Seepage Management	✓	✓	✓	✓
Q	Western C-11 Diversion	✓	✓	✓	✓
R	C-9 Impoundment and Diversion	✓	✓	✓	✓
S	Central Lake Belt Storage	✓	✓	✓	✓
T	C-4 Divide Structures	✓	✓	✓	✓
U	Bird Drive Basin Impoundment	✓	✓	✓	✓
V	L-31N Levee Seepage Management	✓	✓	✓	✓
W	Taylor Creek/Nubbin Slough Storage and Treatment	✓	✓	✓	✓
X	C-17 Backpumping to Water Catchment Area	✓	✓	✓	✓
Y	C-51 East Backpump to Water Catchment Area	✓	✓	✓	✓
BB	Dade Broward Levee Improvement	✓	✓	✓	✓
CC	Improve Broward County Secondary Canals	✓	✓	✓	✓
DD	New Regulation Schedule for Holey Land	✓	✓	✓	✓
EE	Modify Reg Schedule for Rotenberger	✓	✓	✓	✓
FF	Construction of S-356 A and B Structures	✓	✓	✓	✓
GG	Lake Okeechobee ASR	✓	✓	✓	✓
II	Modify G-404 Structure (ECP)	✓	✓	✓	✓
KK	LNWR Internal Canal Structures	✓	✓	✓	✓
LL	C-51 Regional Ground Water ASR	✓	✓	✓	✓
OO	Modifications to South Dade in southern portion of L-31N and C-111	✓	✓	✓	✓
UU	C-23/24/Northfork and Southfork Storage Reservoirs	✓	✓	✓	✓
DDD	Caloosahatchee Backpumping w/STA	✓	✓	✓	✓

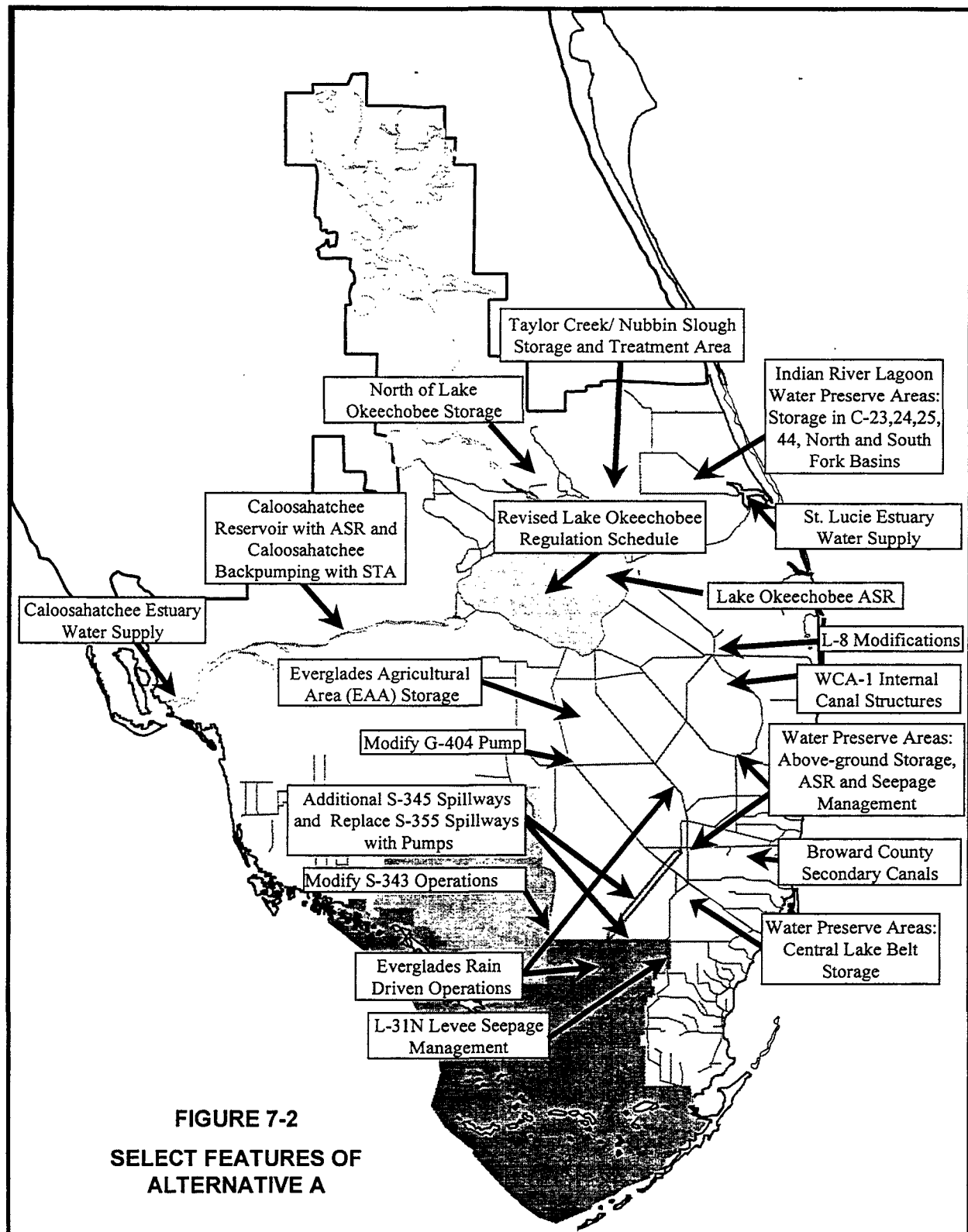
✓ - indicates that the component is included in the respective alternative

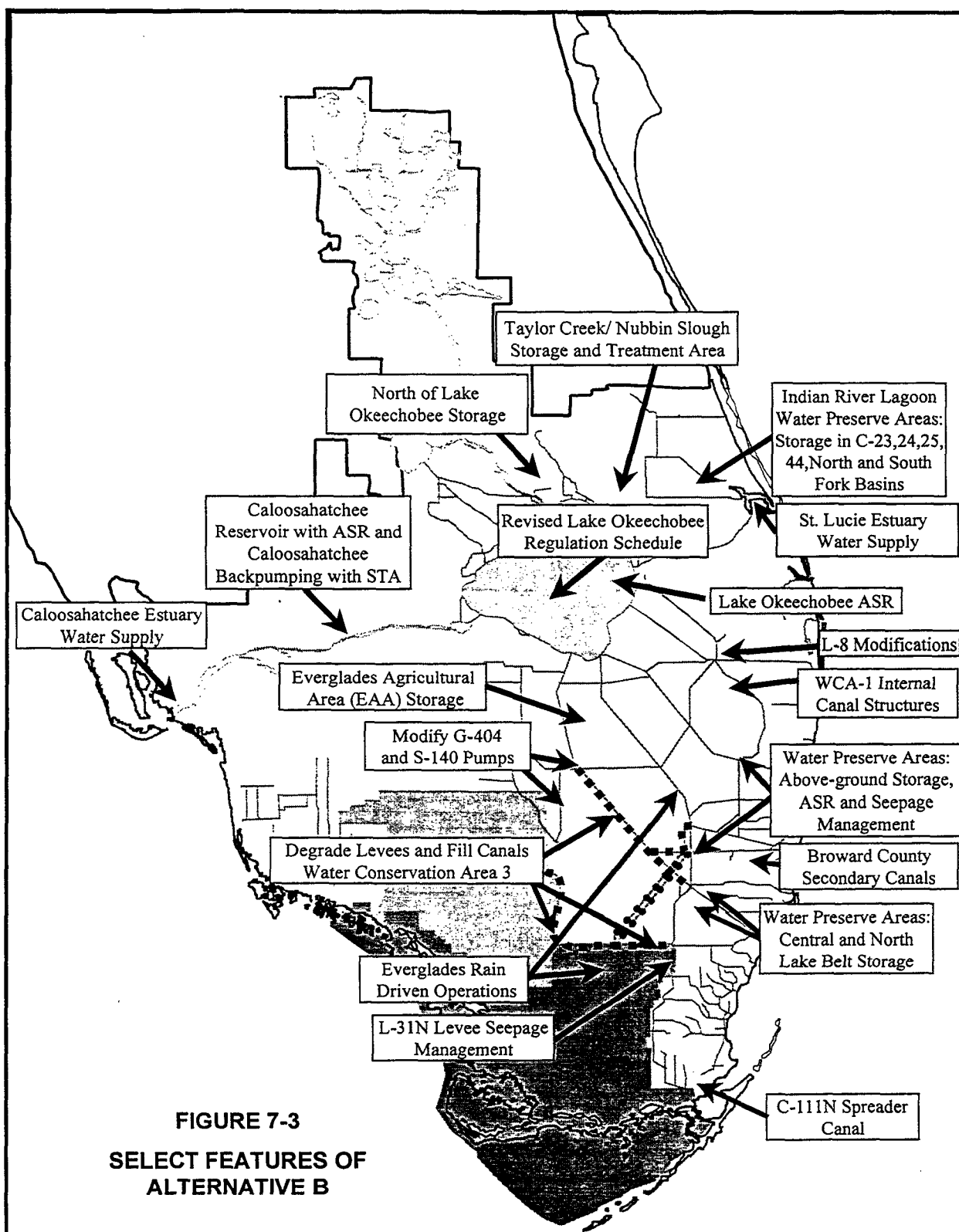
TABLE 7-6
COMPONENTS DIFFERENT IN ALTERNATIVES A - D

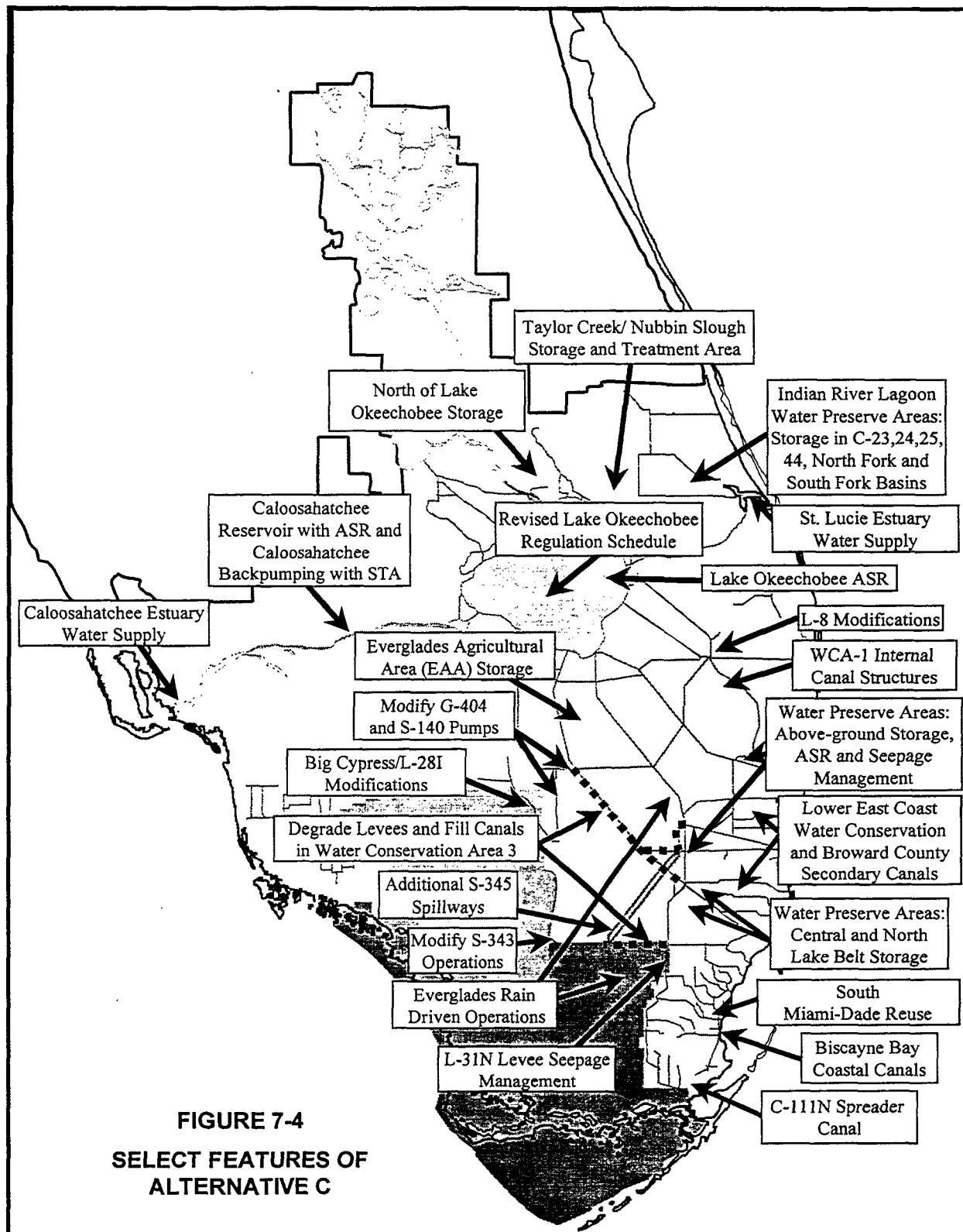
Component		Alternatives			
Title		A (Alt 3 Rev)	B (Alt 4 Rev)	C (Alt 5 Rev)	D (Alt 6)
I	Improve Conveyance between Water Conservation Area-3B and ENP	✓	Merged with QQ		
N	Water Conservation Area-2 B Levee Seepage Management	✓	Merged with YY		
P	North New River Diversion and Treatment	✓	Merged with YY		
AA	Additional S-345 Structures	✓		✓	✓
HH	Modify S-343 A&B Operations	✓		✓	✓
MM	Hillsboro Canal Basin Regional Groundwater ASR	✓	✓	✓	
PP	Backpumping of the C-7 Basin to the Central Lake Belt Storage System via the C-6 Canal	✓			
QQ	Decomartmentalize Water Conservation Area-3		✓	✓	✓
RR	Flow to Central Water Conservation Area 3A		✓	✓	✓
SS	Relocate Miami Canal Water Supply Deliveries to NNR		✓	✓	✓
VV	Palm Beach County Agriculture Reserve Reservoir		✓	✓	✓
WW	C-111N Spreader Canal		✓	✓	✓
XX	North Lake Belt Storage		✓	✓	✓
YY	Divert Water Conservation Area-2 flows to Central Lake Belt Storage		✓	✓	✓
ZZ	Divert Water Conservation Area-3A/3B flow to Central Lake Belt or South Dade			✓	✓
AAA	Lower East Coast Water Conservation			✓	✓
BBB	South Dade County Reuse			✓	✓
CCC	Big Cypress L-28I Modifications			✓	✓
EEE	Flow to eastern Water Conservation Area-3B			✓	✓
FFF	Biscayne Bay Coastal Canals			✓	✓
GGG	C-51/Southern L-8 Reservoir				✓
HHH	West Dade Reuse				✓

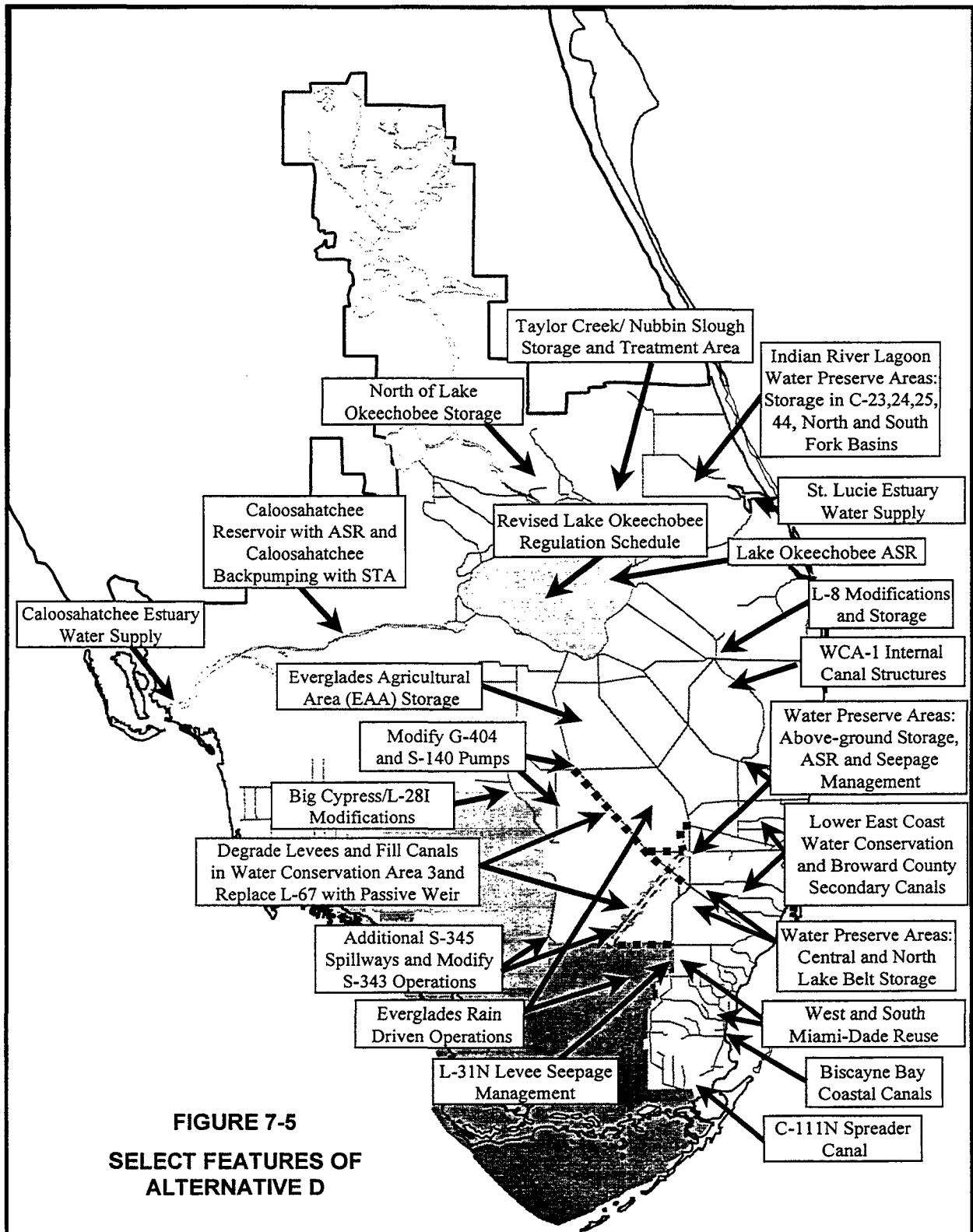
✓ - indicates that the component is included in the respective alternative

Components J, Z, JJ, NN and TT are not included in alternatives A-D









7.3.2.4 River of Grass Evaluation Methodology, Alternatives A - D

The River of Grass Evaluation Methodology (*Appendix D*) was a tool used to determine the habitat quality of the alternative plans based on a subset of the performance measures. The methodology provided a process to select key performance measures, by sub-region, that are critical to achieving the ecologic objectives. Through mathematical equations and best professional judgement, each set of performance measures was normalized to generate a numeric score between 0 and 1.0. The result is a value that represents the habitat quality based on the relationship between hydrologic characteristics and habitat restoration targets. For water supply, a similar method of developing numerical output was followed to allow comparison of the plans relative to the water supply objectives.

The output from this analysis was used to compare the relative differences in habitat quality between alternative plans for each sub-region. It was not used to compare the habitat quality of one sub-region with the habitat quality of another sub-region. For example, it is appropriate to compare results for Shark River Slough to determine how well each alternative plan performed for that region. However, because different equations were used for each sub-region, it is not appropriate to make a comparison between Shark River Slough and Lake Okeechobee. The numeric scores are presented in *Table 7-7* and are explained in *Appendix D*, which includes a detailed interpretation of the effect of the alternative plans on the sub-regions. Alternative Plan D-13R which is included in this table is discussed in *Section 7.3.3*.

7.3.2.4.1 Summary Evaluation Criteria, Alternatives A-D

The Alternative Evaluation Team made its final comparisons of the alternative plans by using three summary evaluation criteria:

- plan ranking
- plan grade
- plan color

These criteria were designed to convert the numerical scores from the River of Grass Evaluation Methodology into more qualitative descriptions of plan performance. Plan rankings compared relative performance among the plans, based on a tally of the ordinal scores created from the numerical scores. Plan grades were created by combining numerical scores, and converting these groupings of scores into letter grades, equivalent to the grading system in academic schools. Color schemes (green for successful, yellow for uncertain; red for unsuccessful) were used to express the team's best professional opinion of how likely each plan will result in the attainment of the long-term ecological or water supply objectives. A

range of numerical scores could be given the same color evaluation, if the sub-team felt that the objectives could be realized within a range of hydrological conditions.

TABLE 7-7
RIVER OF GRASS EVALUATION METHODOLOGY
NUMERICAL SCORES
 (0=lowest, 1=highest)

Sub-Regions	Affected Acres	Alternatives						
		1995	Without Plan	A	B	C	D	D-13R
Lake Okeechobee	467,000	0.6	0.6	0.8	0.8	0.9	0.9	0.9
Caloosahatchee Estuary	9,000	0	0.1	1.0	1.0	1.0	1.0	1.0
St. Lucie Estuary	5,000	0	0.1	0.8	0.8	0.8	0.8	0.9
Loxahatchee National Wildlife Refuge	143,000	1.0	0.6	1.0	1.0	1.0	1.0	1.0
Water Conservation Area-2A	105,000	0.4	0.4	0.4	0.4	0.4	0.4	0.6
Water Conservation Area-2B	28,000	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Northwest Water Conservation Area-3A	118,000	0.1	0.4	0.8	0.8	0.8	0.8	0.8
Holey Land and Rotenberger WMAs	61,000	0.4	0.6	0.8	0.8	0.8	0.8	0.8
Northeast Water Conservation Area-3A	54,000	0.1	0.4	0.8	0.6	0.1	0.1	0.4
Eastern Water Conservation Area-3A	74,000	0.1	0.4	0.1	0.1	0.1	0.1	0.4
Central and Southern Water Conservation Area-3A	276,000	0.4	0.4	0.8	0.8	0.4	0.4	0.8
Water Conservation Area-3B	69,000	0.8	0.4	1.0	0.1	0.1	0.1	0.6
Pennsuco Wetlands	18,000	0.4	0.4	0.6	0.6	0.8	0.8	0.8
Shark River Slough	204,800	0.2	0.3	0.5	0.6	0.6	0.6	0.8
Rockland Marl Marsh	77,000	0.2	0.6	0.7	0.7	0.8	0.8	0.8
Model Lands	18,000	0.6	0.6	0.5	0.7	0.8	0.8	0.8
Florida Bay	448,000	0.2	0.3	0.8	0.9	0.8	0.8	0.8
Biscayne Bay	138,000	0.9	0.8	0.5	0.6	0.8	0.8	0.8
South and Southeast Big Cypress	364,000	0.9	0.9	1.0	0.9	1.0	1.0	1.0
Lake Okeechobee Service Area	N/A	0.6	0.3	0.8	0.7	0.8	0.9	0.9
Lower East Coast Service Area	N/A	0.8	0.7	0.9	0.9	1.0	1.0	1.0

Ranking of the Alternative Plans: For each sub-region, the alternative plans and the Without Plan Condition were ranked from one through five. The best plan for each sub-region was awarded a one (1) and the worst plan a five (5). Ties were dealt with by averaging. For example, if two plans were tied for first place, they each received a score of 1.5, the average of 1 and 2. If three plans tied for first place, they each received a score of 2, the average of 1, 2, and 3. This system ensured that fifteen points for each sub-region were allocated across the alternatives, equalizing the contribution of each sub-region to the final sum of rankings. The results of this evaluation are included in *Table 7-8*. The plan with the lowest cumulative score received the highest rank. For example, Plan D, the highest ranked plan, scored 44 points compared to the Without Plan condition which received 98 points.

TABLE 7-8
PERFORMANCE OF THE WITHOUT PLAN CONDITION AND
ALTERNATIVES
BASED ON RELATIVE RANKING
 (1=best, 5=worse)

Subregion	Alternatives				
	Without Plan	A	B	C	D
Lake Okeechobee	5	3.5	3.5	1.5	1.5
Caloosahatchee Estuary	5	2.5	2.5	2.5	2.5
St Lucie Estuary	5	2.5	2.5	2.5	2.5
Lake Worth Lagoon	5	4	1	2.5	2.5
Holey Land & Rotenberger Wildlife Management Areas	3	3	3	3	3
Loxahatchee National Wildlife Refuge	5	4	2	2	2
Water Conservation Areas 2 & 3	5	1	3	3	3
Shark River Slough	5	4	1.5	3	1.5
Rockland Marl Marsh	5	3.5	3.5	2	1
Model Lands	4	5	2	2.5	1.5
Florida Bay	5	1.5	1.5	3.5	3.5
Biscayne Bay	2.7	4.3	4.3	2.2	1.5
Southern Big Cypress	4	4	4	2	1
Southeastern Big Cypress	5	2	4	2	2
Connectivity	5	4	1	2	3
Sheet Flow	5	4	1	2.5	2.5
Fragmentation	4.5	4.5	1	2.5	2.5
Water Quality	5	3.5	3.5	1.5	1.5
Dade Agricultural Area	5	2.5	2.5	2.5	2.5
Lake Okeechobee Service Area	5	3	4	2	1
Lower East Coast Service Area	5	3.5	3.5	1.5	1.5
Total Sum of Rankings	98.2	69.8	54.8	48.7	44

Grading the Alternative Plans: Plan grades were created based on the numerical output from the River of Grass Evaluation Methodology for most sub-regions. All sub-regions except the Northern and Central Everglades, which developed letter grades independently, assigned letter grades (A, B, C, D, or F) based on the numerical scores (refer to *Table 7-7*). The results of this evaluation are included in *Table 7-9*. Letter grade A was best, or excellent at meeting the performance measures; and letter grade F was worst, or failed to meet the performance measure targets, just like the letter grading system used in academia. The letter grades indicate how well each alternative plan and the Without Plan Condition performed at meeting the performance measure targets. If two or more of the plans performed similarly for the performance measures for the sub-region, then more than one plan could receive a similar grade for a sub-region. For example, Loxahatchee National Wildlife Refuge earned a letter grade A for alternative plans A-D.

TABLE 7-9
PERFORMANCE OF THE WITHOUT PLAN CONDITION AND
ALTERNATIVES
RELATIVE TO PERFORMANCE MEASURES
LETTER GRADE

Sub-region	Alternatives				
	Without Plan	A	B	C	D
Lake Okeechobee	C	B	B	A	A
Caloosahatchee Estuary	F	A	A	A	A
St Lucie Estuary	F	C	C	C	B+
Lake Worth Lagoon	F	D	B	C	C
Holey Land & Rotenberger Wildlife Management Areas	C	B	B	B	B
Loxahatchee National Wildlife Refuge	C	A	A	A	A
Water Conservation Areas 2 & 3	D	C	D	D	D
Shark River Slough	F	F	D	D	D
Rockland Marl Marsh	D	C	C	B	B
Model Lands	F	F	C	B	B
Florida Bay	F	C	C	C	C
Biscayne Bay	C	F	F	C	B
Southern Big Cypress	B	B	B	B	A
Southeastern Big Cypress	B	A	B	A	A
Connectivity	D	D	A	B	B
Sheet Flow	F	B	B	B	B+
Fragmentation	F	F	A	B	B
Lake Okeechobee Service Area	F	B	C	B	A
Dade Agricultural Area	F	A	A	A	B
Lower East Coast Service Area	D	B	B	A	A
Water Quality	D	C	C	C	C

Color Assessment of the Alternative Plans: The alternative plans were also scored using colors (green, yellow, and red) by converting plan grades into a "best professional opinion" prediction of how likely each plan would achieve the long-term ecological or water supply objectives. The results are displayed in *Table 7-10*. Each color provides two kinds of information: (a) a prediction of how likely a plan will achieve the recovery and long-term sustainability objectives defined by the performance measure(s); and (b) a recommended priority for further improvement in the design and operation of the currently modeled plan. Green means that the current plan is likely to recover and sustain the ecological or water supply objective described by the performance measures. Yellow means that achievement of the long-term objectives is marginal or uncertain, and that improvement in the plan is a moderate priority. Red means that the recovery and long-term sustainability of the objectives are unlikely, and that the current plan requires improvement if these targets are to be met.

TABLE 7-10
PERFORMANCE OF THE ALTERNATIVE PLANS
TO ACHIEVE LONG-TERM OBJECTIVES
COLOR RANKING

G = successful, Y = marginal or uncertain, R = unsuccessful

Sub-region	Alternatives				
	Without Plan	A	B	C	D
Lake Okeechobee	Y	G	G	G	G
Caloosahatchee Estuary		G	G	G	G
St Lucie Estuary		Y	Y	Y	Y
Lake Worth Lagoon	Y			Y	Y
Holey Land & Rotenberger Wildlife	Y	G	G	G	G
Loxahatchee National Wildlife Refuge	Y	G	G	G	G
Water Conservation Area 2 & 3		Y			
Shark River Slough					
Rockland Marl Marsh		Y	Y	G	G
Model Lands			Y	G	G
Florida Bay		Y	Y	Y	Y
Biscayne Bay	Y			Y	G
Southern Big Cypress	Y	Y	Y	Y	G
Southeastern Big Cypress	Y	G	Y	G	G
Connectivity	Y	Y	G	G	G
Sheet Flow		G	G	G	G
Fragmentation			G	G	G
Dade Agricultural Area		G	G	G	Y
Lake Okeechobee Service Area		G	Y	G	G
Lower East Coast Service Area		Y	Y	G	G
Water Quality	ne	ne	ne	ne	ne

ne – not evaluated using color ranking

7.3.2.4.2 Keystone and Endangered Species Evaluation of Alternatives A-D

Evaluation of alternative plans' performance with regard to threatened, endangered and keystone species was accomplished through a combination of several methods. The Across Trophic Levels System Simulation model results provided information on expected biological responses of several species and species groups. Other methods to predict species response to the alternative plans included: (1) the additional Crocodile Habitat Suitability and Wood Stork Nesting Patterns performance measures; (2) information on known hydrological responses of species gleaned from Volume I of the *Multispecies Recovery Plan* for the Threatened and Endangered Species of south Florida, Technical/Agency Draft -(U.S. Fish and Wildlife Service, 1998b); and (3) discussions with research biologists widely recognized as experts on particular species. These additional sources of information were considered along with results from the Across Trophic Level System Simulation model to form a "weight of the evidence" or "consensus" conclusion among members of the Restudy Team and species experts. The relative ranking of the plans for the keystone and endangered species are included in *Table 7-11*.

TABLE 7-11
KEYSTONE AND LISTED SPECIES
(1=best, 5=worse)

Species	Alternatives				
	Without Plan	Alt A	Alt B	Alt C	Alt D
CSS Sparrow	5	4	1	1	1
Snail Kite	5	3	3	1	1
Wood Stork	5	1	1	1	1
Panther	1	1	1	1	1
Crocodile	5	2	2	2	1
Deer	5	2	1	2	2
Wading Birds	5	3	3	1	1
Fish	5	3	3	1	1

7.3.2.4.3 Water Quality Evaluation of Alternatives A - D

Model output from the South Florida Water Management Model and the water quality models were evaluated in the context of performance measures developed by the Restudy Water Quality Team. The Water Quality Team's empirical evaluation was conducted on a slightly different sub-regional basis than the Alternative Evaluation Team. The Water Quality Team did not develop an empirical evaluation of alternative plans on water quality conditions in the Big Cypress Basin or the Holey Land and Rotenberger Wildlife Management Areas. For those areas, a qualitative assessment was made based upon the proposed operation of the components contained in the alternatives.

From this evaluation, the Water Quality Team ranked the base conditions and alternative plans on a scale of 1 to 6, with higher scores indicating a more preferred condition from a water quality perspective. It should be noted that this method of ranking is reverse from the previous ranking evaluations, meaning a lower score indicates a more preferred condition. The rankings are included in *Table 7-12*.

TABLE 7-12
WATER QUALITY RANKINGS
1=worse, 6=best¹

Sub-Region	1995 Base	Alternatives				
		Without Plan	A	B	C	D
Lake Okeechobee	1.5	4.5	1.5	4.5	4.5	4.5
Everglades Agricultural Area and the Everglades Construction Project	1	2	6	5	3.5	3.5
Water Conservation Areas 2 & 3	1	2.5	5	2.5	5	5
St. Lucie Watershed	1	2	3.5	3.5	5	6
Caloosahatchee Watershed	1.5	1.5	3	4	5	6
Loxahatchee National Wildlife Refuge	1	2	4.5	4.5	4.5	4.5
Everglades National Park	1.5	5	3.5	6	1.5	3.5
Lower East Coast Service Area	6	3.5	1.5	1.5	5	3.5
<i>Cumulative Score</i>	<i>14.5</i>	<i>23</i>	<i>28</i>	<i>31.5</i>	<i>34.0</i>	<i>36.5</i>

¹ Care should be taken when comparing the water quality rankings with other evaluation rankings due to the differences in scale.

7.3.2.4.4 Evaluation Conclusions for Alternatives A - D

Results presented in the previous tables show that Alternative D is generally the best plan at achieving the ecologic, water supply, and water quality objectives. For these same criteria, Alternative C is the second best plan. *Table 7-11* shows that for Listed Species, Alternative D ranks slightly higher than the other alternatives, with Alternative C ranking second. All tables show that for most sub-regions, the plans provide substantial benefits (i.e., improvements) over the Without Plan Condition.

The Alternative Evaluation Team selected Alternative D, with the provision that steps be taken to correct specific weaknesses in the alternative. Overall, Alternative D performed best for:

- Lake Okeechobee Service Area
- Caloosahatchee Estuary

- Lake Okeechobee Service Area
- Lower East Coast Service Areas
- Loxahatchee National Wildlife Refuge
- Holey Land and Rotenberger Wildlife Management Areas
- Southern and southeastern Big Cypress Basin
- Southern Everglades Rocky Glades

Alternative D, was inadequate (reds in *Table 7-10*) at meeting performance targets for:

- Portions of Water Conservation Areas 2 and 3
- Shark River Slough

Alternative D was moderately adequate (yellows in *Table 7-10*) at meeting performance targets for:

- St. Lucie Estuary
- Florida Bay
- Lake Worth Lagoon
- South Dade Agricultural Region

From a water quality perspective, Alternatives C and D were preferred over Alternatives A and B. The Without Plan Condition was considered not acceptable. Due to a lack of model results (particularly the Everglades Landscape Model results), the alternative plans could not be ranked based upon water quality impacts or benefits in Big Cypress National Preserve and the Holey Land and Rotenberger Wildlife Management Areas.

The Alternative Evaluation Team recommended that ad hoc teams of ecologists, hydrologists and modelers be created to determine both the immediate and long-term strategy for improving the performance of Alternative D in the red and yellow scored areas.

The Alternative Evaluation Team also highlighted three specific strengths of Alternative B, which, if incorporated into Alternative D, would bring the different ecological strengths of these two plans together to form a more robust restoration plan. These included:

- Higher volumes of flow into the Florida Bay Estuary compared to other plans.
- Greater success at reestablishing system connectivity.
- Improved levels of sheet flow, compared to other plans.

These three features were a consequence of the greater extent of system-wide decompartmentalization, by the removal of levees and canals that create barriers between natural areas, which characterized Alternative B. The Alternative Evaluation Team recommended that the same ad hoc team explore the feasibility of merging these features of Alternative B into D.

At a Restudy Team meeting in early June 1998, the full team agreed with the conclusions of the Alternative Evaluation Team and selected Alternative D as the preferred alternative. The full team also accepted the Alternative Evaluation Team's recommendation that Alternative D should be refined to improve performance in five key areas: Water Conservation Areas 2 and 3, Shark River Slough, Florida Bay, and the St. Lucie Estuary.

7.3.3 Initial Draft Plan

In June 1998, a team of engineers and ecologists conducted an intense iterative process to improve the hydrologic performance of Alternative D in the five key areas. During the first seven iterations, the team attempted to achieve the improved performance by making only operational changes. However, such changes proved inadequate to meet the desired performance, and structural changes to the plan were considered. The next six iterations included both operational changes and structural changes to achieve the desired performance. The thirteenth and final iteration included component modifications and improvements to Alternative D that rectified performance inadequacies in portions of the Water Conservation Area, Everglades National Park, Florida Bay, and the St. Lucie Estuary. The plan that resulted was called Alternative D-13R. Alternative D-13R was designated as the Initial Draft Plan by the Restudy Team.

7.3.3.1 Features of Alternative D-13R

The most significant change between Alternative D and D-13R was the removal of additional levees and canals between Water Conservation Area 3A and Everglades National Park and Big Cypress National Preserve. Unlike Alternative B, Alternative D-13R left a barrier between Water Conservation Areas 3A and 3B. This barrier, a levee known as L-67, was modified in Alternative D-13R to include a conveyance canal and a series of passive weirs to promote high flows between these areas, in addition to allowing for managed flows during the dry season. Alternative D-13R also included several new operating rules for triggering when surface water is allowed to enter the Water Conservation Areas and Everglades National Park. Furthermore, additional surface water storage capacity was included for the C-23, C-24, Northfork and Southfork Basins in the Upper East Coast to further reduce damaging local basin runoff to the St. Lucie Estuary. The major features of Alternative D-13R are displayed in *Figure 7-6*. For a complete description of this plan, refer to *Appendix A, Section 4*.

7.3.3.2 Evaluation of Alternative D-13R

The modifications to Alternative D resulted in substantial improvements in the Water Conservation Areas and Everglades National Park without compromising Lake Okeechobee water levels or water supply to Lake Okeechobee and Lower East Coast Service Areas. The modifications relieved adverse high and low water conditions in the Water Conservation Areas. Flow volumes to Shark River Slough were increased while maintaining seasonal distribution of flows indicated by Natural System Model. The number of dry-downs in Shark River Slough was reduced to three events over the period of record compared to two events under Natural System Model. Salinity in Florida Bay coastal basins was improved as well. These improvements were achieved through partial decompartmentalization of Water Conservation Area 3 and Everglades National Park, which makes Alternative D-13R more like Alternative B as desired by the Alternative Evaluation Team and the Restudy Team. Additional storage acreage in the Upper East Coast basins reduced high volume local basin runoff to the St. Lucie Estuary. This enabled Alternative D-13R to come closer to meeting the performance measure target described by the number of times high local basin runoff occurred to the estuary.

Table 7-13 is a summary table of letter grades for the Without Plan Condition, and Initial Draft Plans D and D13R. *Table 7-14* shows the same by color ranking. *Table 7-7* includes the River of Grass Evaluation Methodology results for Alternative D-13R. A separate water quality evaluation was also conducted for Alternative D-13R (*see Appendix D*). From a water quality perspective, the performance of Alternative D-13R was improved when compared to Alternative D.

7.3.3.3 Uncertainty Analysis of D-13R Components

In selecting the components that are in Alternative D-13R, the Restudy Team recognized the high level of technical and implementability (due to high cost) uncertainties associated with some of the components. These uncertainties can be viewed as a question of whether an uncertain component will achieve the desired effect. If the component fails to achieve the desired effect, the feasibility of implementing an alternative component along with or as a replacement to the uncertain component may need to be considered to assure that the Comprehensive Plan meets its stated objectives.

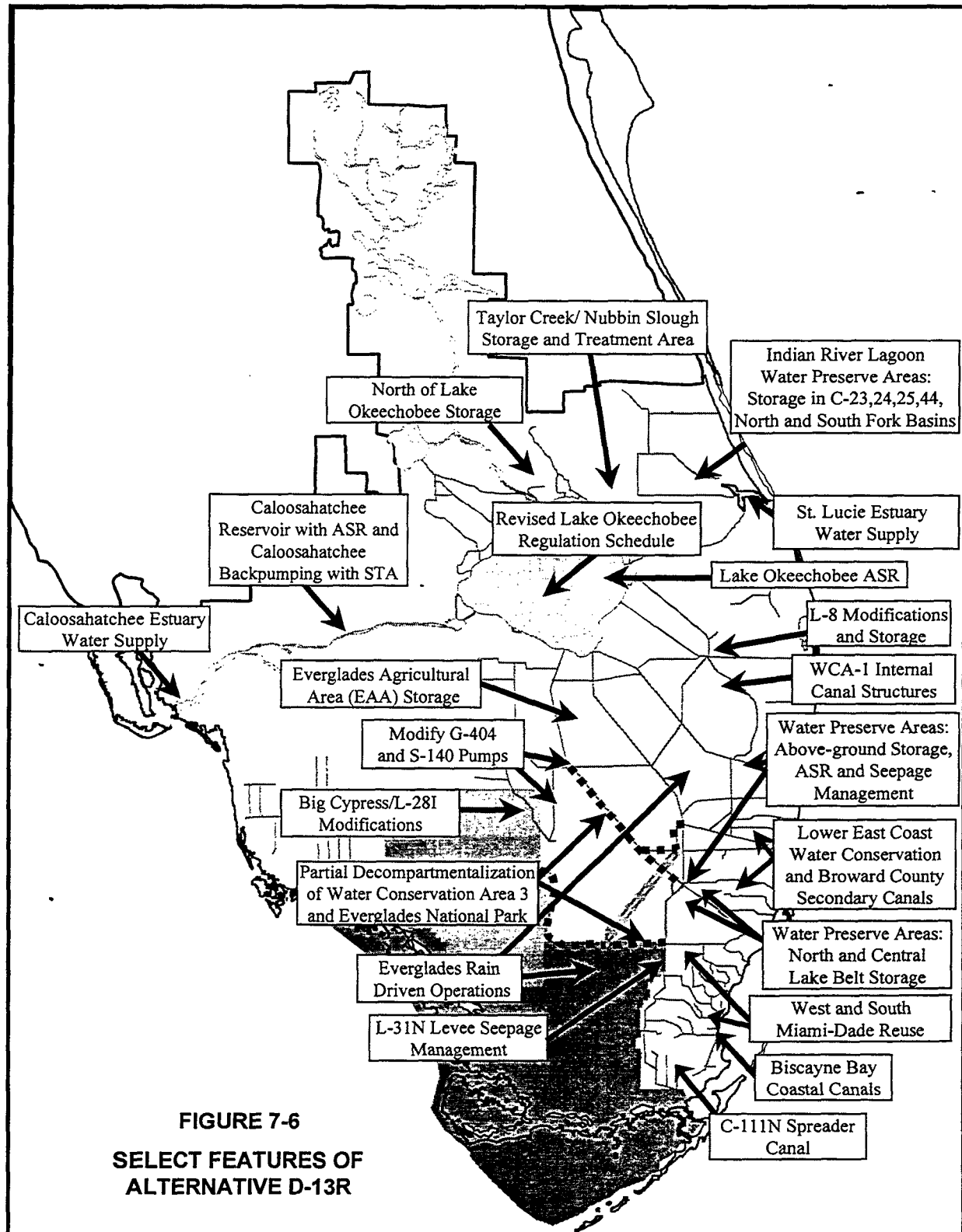





TABLE 7-13
PERFORMANCE OF D & D13R
RELATIVE TO ECOLOGICAL PERFORMANCE
MEASURES
LETTER GRADE

Sub-Region	Without Plan	Alt D	D-13R
Lake Okeechobee	C	A	A
Caloosahatchee Estuary	F	A	A
St Lucie Estuary	F	C	B+
Lake Worth Lagoon	F	C	C
Holey Land & Rotenberger WMA	C	B	B
Loxahatchee NWR	C	A	A
Water Conservation Area 2A	 D 	D	C
Water Conservation Area 2B		F	F
Northwestern Water Conservation Area 3A		B	B
Northeastern Water Conservation Area 3A		F	D
Eastern Water Conservation Area 3A		F	D
Central & Southern Water Conservation Area 3A		D	B
Water Conservation Area 3B		F	C
Pennsuco Wetlands	ne	B	B
Shark River Slough	F	D	B
Rockland Marl Marsh	D	B	B
Florida Bay	F	C	B
Biscayne Bay	C	B	B
Model Lands	F	B	B
Southern Big Cypress	B	A	A
SE Big Cypress	B	A	A
Connectivity	D	B	B+
Sheet Flow	F	B	B
Fragmentation	F	B	A
Water Quality	D	C	C

ne – not evaluated

TABLE 7-14
PERFORMANCE OF D AND D-13R
TO ACHIEVE LONG-TERM ECOLOGICAL OBJECTIVES
COLOR RANKING

Sub-Region	Without Plan	Alt D	D-13R
Lake Okeechobee	Y	G	G
Caloosahatchee Estuary	R	G	G
St Lucie Estuary	R	Y	G
Lake Worth Lagoon	Y	Y	Y
Holey Land & Rotenberger WMA	Y	G	G
Loxahatchee NWR	Y	G	G
Water Conservation Area 2A		R/Y	G/Y
Water Conservation Area 2B		R	R
Northwestern Water Conservation Area 3A		G	G
Northeastern Water Conservation Area 3A		R	Y
Eastern Water Conservation Area 3A		R	Y
Central & Southern Water Conservation Area 3A		R/Y	G/Y
Water Conservation Area 3B		R	Y
Pennsuco Wetlands	ne	G	G
Shark River Slough	R	R	G
Rockland Marl Marsh	R	G	Y
Florida Bay	R	Y	G
Biscayne Bay	Y	G	G
Model Lands	R	G	G
Southern Big Cypress	Y	G	G
SE Big Cypress	Y	G	G
Connectivity	Y	G	G
Sheet Flow	R	G	G
Fragmentation	R	G	G
Water Quality	ne	ne	ne

ne – not evaluated

To understand the extent of these uncertainties, the team identified contingency plans to address potential performance deficiencies or cost-effectiveness problems related to these uncertain components. As a first step in identifying the scope of contingency plans, the Restudy Team identified the components with the highest degree of uncertainty and the most likely alternatives that could be implemented as partial or complete substitutes for the uncertain components. The team also identified the sources of the uncertainty as well as the contribution these components make to the overall system. The results of this investigation are included in *Table 7-15*.

In addition, sensitivity analyses were conducted for the uncertain components using the South Florida Water Management Model. These computer simulations were evaluated to determine the extent of degraded performance. The results are documented in *Section 7.3.3.4*.

7.3.3.4 Sensitivity Analysis of D-13R Components

Special investigations were undertaken to assess the sensitivity of Alternative D-13R (Appendix B). The analysis included removing components or reducing efficiency of components with the highest uncertainty from Alternative D-13R and then analyzing the simulated performance of D-13R under these conditions. These simulations were undertaken, in addition to other special investigations, at various stages in the alternative development process in order to assist in the design of alternatives or to investigate particular effects that could not be built into the alternatives. Although some of the sensitivity analyses indicate that the overall system performance does not change significantly when certain components are removed, this does not necessarily mean that the feature is not important or needed. No operational modifications or structural components were added to replace the function of the removed components. It was found that one or more of the remaining components was typically utilized more extensively to compensate for the removal of a component.

TABLE 7-15
COMPONENT UNCERTAINTY

Component	Key Performance Attributes of Component	Sources of Uncertainty	Potential Alternatives	Expected Downsides of Potential Alternatives
Lake Okeechobee ASR	A. Attenuates high Lake levels B. Keeps Lake levels up in dry periods C. Greatly reduces regulatory releases to Caloosahatchee and St. Lucie Estuaries D. Stores excess water for future use	1. High construction and O&M costs, especially potential treatment costs for water to be stored 2. Technical uncertainty, especially as regards how much water can ultimately be recovered	a) Increase storage by raising levels in Lake Okeechobee (B, C, D) (1, 2) b) Partition Lake into ecologically and water supply managed areas (A, B, C, D) (1, 2) c) Expand capacity of reservoirs in Alternative D13-R that can store Lake water, by making them larger and/or deeper (A, B, C, D) (2) d) New reservoir(s) (A, B, C, D) (2) Deep disposal wells (A, C) (1, 2)	<ul style="list-style-type: none"> Increased evapotranspiration or loss of water to saline aquifers (c, d) Negative ecological impact on Lake (a, b) Higher Costs (c, d)
Lower East Coast ASR	A. Improves efficiency of reservoirs B. Reduces flows to tide (Lake Worth Lagoon) C. Stores water for future use	1. Technical uncertainty, especially as regards how much water can ultimately be recovered 2. High construction and O&M costs, especially potential treatment costs for water to be stored	a) Deepen surface storage reservoirs (B, C) (1) b) Construct new or expand reservoirs (include alternative location) (B, C) (1) c) Alternative water sources including reuse and Floridan aquifer water with membrane treatment (1)	<ul style="list-style-type: none"> Higher costs (a, b, c) Additional Land Required for Water Management (b)
Caloosahatchee ASR	A. Reduces excessive flows and helps meet minimum flows to Caloosahatchee Estuary B. Improves efficiency of reservoir C. Stores water for future use	1. Technical uncertainty, especially as regards how much water can ultimately be recovered	a) Deeper surface storage (A, C) (1) b) New expanded reservoirs (include alternative location) (A, C) (1) c) Deep disposal wells (A – excessive)	<ul style="list-style-type: none"> Increased Evapo-transpiration or loss of water to saline aquifers (b) Higher Costs (a, b) Additional Land Required for Water Management (b)
North Lake Belt	A. Water supply to canal system B. Reduce deliveries from WCA/L C. Maintain canal stages (C-2, C-4, C-6, C-7, C-9) D. Flood protection	1. Ability to fluctuate levels in storage area may be limited by influx of poor quality water from deeper aquifers	a) Configure North Lake Belt Storage Reservoir with more above ground level storage capacity b) ASR if technical and cost uncertainties are successfully solved c) Alternative water supply/R.O./Reuse d) Store water in an alternative surface storage area which may be located locally or in the EAA	<ul style="list-style-type: none"> Usable storage may still be reduced (a, c) Costs per unit of storage capacity may be higher(b,d)

TABLE 7-15
COMPONENT UNCERTAINTY

Component	Key Performance Attributes of Component	Sources of Uncertainty	Potential Alternatives	Expected Downsides of Potential Alternatives
Central Lake Belt	A. Reduces high stages in WCAs and ENP B. Improves dry season flows to ENP	1. Ability to fluctuate levels in storage area may be limited by influx of poor quality water from deeper aquifers	a) Configure Central Lake Belt Storage Reservoir with more above ground level storage capacity b) Intercept water – store in EAA for later use c) Deepen above ground reservoirs in Alternative D13 such as C-9, C-11 and Bird Drive d) Increase delivery of water from west Dade to ENP	<ul style="list-style-type: none"> Usable storage may still be reduced (a, c) Costs per unit of storage capacity may be higher (a, b, c) Coastal basin water shortages may be increased and flows to Biscayne Bay may be reduced (d)
Reuse – South Dade	A. Provides a base flow to Biscayne National Park B. Helps prevent saltwater intrusion by providing water to maintain canal and groundwater levels	1. Funding due to high costs related to treatment operations and maintenance 2. Treatment effectiveness and reliability	a) ASR if ASR technical and cost uncertainties are successfully solved (B) (1) b) In-ground storage (B) (1) c) Alternative water supply – R.O. Conservation (A, B) (1) d) Floridan Aquifer (A,B) e) Alternative surface water sources (A,B)	<ul style="list-style-type: none"> Provides less water for Biscayne Bay when water is being placed into storage (a, b) Quantity and quality of source water uncertainty(d,e)
Reuse – West Dade	A. Provides groundwater recharge for west wellfields B. Reduces deliveries from WCA/LO to Service Area 3 C. Provides flow to Biscayne National Park and to South Dade Conveyance system which helps recharge Taylor Slough D. Provides groundwater recharge to L-31N area from which water is withdrawn to deliver to ENP	1. Funding due to high costs related to treatment operations and maintenance 2. Treatment effectiveness and reliability	a) ASR if ASR technical and cost uncertainties are successfully solved (A, B, D) b) In-ground storage (A, B, D) (1) c) Alternative water supply – reverse osmosis and conservation (A, B, C, D) (1) d) Floridan Aquifer (C) e) Alternative surface water sources (C)	<ul style="list-style-type: none"> Provides less water for uses when water is being placed into storage (a, b) Quantity and quality of source water uncertainty(d,e)
L-31N Seepage Management	A. Provides ability to seasonally manage groundwater seepage out of ENP B. Protects water levels in ENP C. Protects necessary groundwater flows to coastal Miami-Dade County	1. Ability of pumping technology to seasonally manage groundwater seepage 2. Effectiveness and feasibility of the levee seepage barrier and resulting downstream impacts	a) Curtain wall with improved surface water deliveries to enhance coastal basin groundwater recharge b) Partial curtain wall with enhanced surface deliveries to ENP to mitigate for groundwater outflows. c) Seepage collection system	<ul style="list-style-type: none"> Higher costs (a, b) Reduced effectiveness (c)

(A, B, C, etc.) corresponds to key attributes of a component

(1, 2, 3, etc.) corresponds to the uncertainties related to a particular component

(a, b, c, etc.) corresponds to the potential alternative

Due to the high construction, operation and maintenance, and potential treatment costs for water stored in aquifers, and the technical uncertainty regarding the recovery efficiency of aquifer storage and recovery, two sensitivity modeling scenarios were run and evaluated. Modeling scenarios were run and evaluated for each of the aquifer storage and recovery components included in the Caloosahatchee Basin, the Lake Okeechobee area, and the Lower East Coast area. The two scenarios were evaluated against Alternative D-13R. The first scenario considered reduction in recovery efficiency of aquifer storage and recovery from 70 to 35 percent. The second scenario considered total removal of the aquifer storage and recovery component. These sensitivity analyses showed the following results. The scenarios with decreased aquifer storage and recovery efficiency at the Caloosahatchee and Lower East Coast Basins aquifer storage and recovery facilities required additional water from Lake Okeechobee and Water Conservation Area 1 to offset deficits. Scenarios with reduced efficiency for Lake Okeechobee and Lower East Coast Basins aquifer storage and recovery showed increased discharges to tide and more high flows to Lake Worth Lagoon. The scenario removing Lake Okeechobee aquifer storage and recovery more than tripled Lake Okeechobee Zone A regulatory discharges to the St. Lucie Estuary and doubled discharges to the Caloosahatchee Estuary. In addition, when Lake Okeechobee aquifer storage and recovery was removed southerly discharges from the lake to the Everglades Agricultural Storage Area and Water Conservation Areas increased.

In the North and Central Lake Belt Storage Areas, concern was expressed that the ability to fluctuate water levels within the storage areas may be limited due to the potential for introduction of poor quality water from deeper aquifers. Sensitivity analysis modeling scenarios were carried out to individually remove each of these storage components. The removal of the North Lake Belt Storage Area resulted in a significant increase in water deliveries from Lake Okeechobee and Water Conservation Area 3A to the Lower East Coast Service Area 3, to maintain water levels in the canals. As a result, lake stages were lower and there were increases in water restrictions in Lower East Coast Service Area 2 with the reduced ability to maintain coastal canals, and a redistribution of flows to Biscayne Bay. The removal of the Central Lake Belt Storage Area resulted in a significant increase in eastward diversions of excess water from Water Conservation Area 3A and 3B. This resulted in lowered stages in Water Conservation Area 3A and 3B and reduced flows south to Northeast Shark River Slough. Discharges to Biscayne Bay increased as a result of increased seepage from Water Conservation Area 3.

The wastewater reuse components were evaluated due to their high construction, operation and maintenance costs. Removal of the West Miami-Dade reuse component significantly lowered stages in the Bird Drive Recharge Area and in L-31N, decreased flows to Central Shark River Slough and Everglades National Park, lowered Lake Okeechobee stages during droughts, and increased Lake Okeechobee triggered water restrictions in the Lower East Coast Service Area.

Removal of the South Miami-Dade reuse component reduced discharges to Biscayne Bay and slightly increased locally triggered water restrictions in Lower East Coast Service Area 3. Water deliveries from Lake Okeechobee in particular increased to compensate for the removal of the reuse components.

Four Everglades Agricultural Area reservoir sensitivity scenarios were developed and resulting performance was compared to that of Alternative D13-R. Findings show that the 20,000 acre compartment dedicated to capturing Everglades Agricultural Area runoff and meeting Everglades Agricultural Area irrigation needs has a large region-wide benefit. The two-20,000 acre surge tank storage areas, dedicated to capturing excess Lake Okeechobee water and meeting Everglades water needs, are useful for reducing the dependence on Lake Okeechobee for meeting Everglades water needs. The analysis revealed that the adverse system-wide effects from removing the surge tanks were minimized by increased usage of the Lake Okeechobee aquifer storage and recovery component.

Component uncertainty for the L-31N Seepage Management results from concern regarding the effectiveness and feasibility of the levee seepage barrier and resulting downstream impacts and the ability of pumping technology to seasonally manage groundwater seepage. This sensitivity analysis was not modeled, however, the modeling results of the removal of the Central Lake Belt Storage Area and its perimeter seepage barrier could be extrapolated for general analysis. Wet season, groundwater seepage would be expected to raise the L-31N Borrow Canal levels, increase groundwater levels east of L-31N, flows to Biscayne Bay can be expected to increase due to seepage, and stages and hydroperiods in Everglades National Park west of L-31N can be expected to decrease.

7.3.4 Conclusions of Comprehensive Plan Formulation and Evaluation

The Restudy Team formulated and evaluated 10 alternative plans and in excess of 20 intermediate computer simulations (termed scenarios) that culminated in the selection of Alternative D-13R as the Initial Draft Plan. This plan was then further evaluated by identifying components that have a high degree of uncertainty and analyzing the sensitivity of these features. The results of these analyses suggest that Alternative D-13R, even with all of its uncertainties, is the plan that best achieves the planning objectives. However, a number of components had yet to be evaluated because they were outside the purview of the analytical tools being used to evaluate the alternative plans. Therefore, a subsequent analysis was initiated to evaluate these components, which the Restudy Team termed Other Project Elements.

7.4 OTHER PROJECT ELEMENTS

During the iterative plan formulation process, it became apparent that some components could not be evaluated using the South Florida Management Model because either they were outside the boundary of the model or they were too small to be simulated at the scale of the model. These components were termed Other Project Elements (OPEs) and underwent a separate evaluation (See *Appendix A, Section 6*).

An initial list of Other Project Elements was developed by the Restudy Team from a number of sources including: the Critical Projects, the Restudy Plan Formulation document, and new proposals from Restudy Team members.

The Water Resources Development Act (WRDA) of 1996 authorizes the Secretary of the Army, subject to specific criteria, to proceed expeditiously with the implementation of restoration projects that are deemed critical to the restoration of the south Florida ecosystem (see *Appendix A5*). These projects were termed "Critical Projects." This authority resulted in an expedited study to identify projects that would meet the criteria set forth in the authorizing legislation. A total of 35 projects were nominated as Critical Projects under this authority. However, the cumulative cost estimate for these projects exceeded the legislatively mandated limit. Therefore, it is anticipated that only a fraction of the projects will actually be implemented under the Critical Projects authority. Hence, to ensure that all of these projects received full consideration, the Restudy included the Critical Projects that had not yet been approved for construction in its planning process. Some of these Critical Projects are included in alternative plans such as the C-4 Divide Structure. The remainder of the Critical Projects were considered in this Other Project Element evaluation.

7.4.1 Evaluation of Other Project Elements

The first step in the evaluation of the Other Project Elements involved screening the initial list using the following criteria:

- (1) The project element could not be evaluated using the South Florida Water Management Model.
- (2) The project element must support and be consistent with the Restudy planning objectives.
- (3) The project element must have a Federal interest.
- (4) The project element should not be a stand alone research or data collection activity.

This screening resulted in 37 potential Other Project Elements. These were then evaluated by an interagency - interdisciplinary team in four benefit categories including: (1) ecological values based on hydrology, spatial extent, habitat quality, and improvement to native flora and fauna; (2) urban and agricultural water supply, (3) flood damage reduction; and (4) water quality. In addition, the team considered two other parameters including geographic extent and the significance to the Initial Draft Plan.

7.4.2 Conclusions of the Evaluation of the Other Project Elements

Of the 37 potential Other Project Elements, the team rated 26 of them (eleven of them were not rated due to lack of information). Of the 26 rated, 11 of them were recommended to be included with the Initial Draft Plan. Further, many of the other proposed Other Project Elements, including many of the lower-priority Critical Projects, were recommended for further study. However, in response to public and agency comments recommending the implementation of the Comprehensive Plan be accelerated to expedite ecologic restoration, many of these Critical Projects and additional Other Project Elements are now included in the final plan. Accordingly, 21 Other Project Elements are now recommended for inclusion in the Comprehensive Plan as displayed in *Table 7-16*.

7.5 FINAL ARRAY OF ALTERNATIVE PLANS

Subsequent to the selection of Alternative D-13R as the Initial Draft Plan, an evaluation of the final array of alternative plans was conducted. This included an analysis of the economic benefits and impacts, an analysis of the environmental planning objectives, a cost effectiveness and incremental analysis, mitigation analysis, and an evaluation of the plans to meet various policy and regulatory requirements.

7.5.1 Economic Evaluation of the Alternative Plans

Many of the benefits afforded by the alternative plans are environmental in nature and were not converted to monetary units for evaluation. As a result, a major focus of the economic evaluation was on the cost effects of the alternatives. Such effects can result at both the national and regional levels.

**TABLE 7-16
RECOMMENDED OTHER PROJECT ELEMENTS**

Other Project Elements Title	CP ¹ Rank
Melaleuca Eradication – Renovation of Existing Facility and Biological Agent Rearing components (CP)	3
Seminole Tribe Big Cypress Reservation Water Conservation Plan (CP)	6
Southern Golden Gate Estates Hydrologic Restoration (CP)	7
Southern CREW Project Addition/Imperial River Flowways (CP)	9
Lake Okeechobee Watershed Water Quality Treatment Facilities (includes Lake Okeechobee Water Retention/Phosphorus Removal (CP))	10
Lake Trafford Restoration (CP)	15
Biscayne Bay Coastal Wetlands (includes L-31E Flow Redistribution (CP)	16
Henderson Creek Belle and Meade Restoration (CP)	17
Lake Okeechobee Tributary Sediment Dredging (CP)	18
Florida Keys Tidal Restoration (CP)	22
Lake Worth Lagoon Restoration (CP)	23
Palm Beach County. Wetlands Based Water Reclamation Project (CP)	24
Miccosukee Water Management Plan (CP)	26
Lakes Park Restoration (CP)	31
Palm Beach County Winsberg Farms Constructed Wetlands Project (CP)	33
Restoration of Pineland & Tropical Hardwood Hammocks in C-111 Basin (CP)	35
Lake Istokpoga Regulation Schedule	N/A
Protect & Enhance Existing Wetland Systems along Loxahatchee National Wildlife Refuge including Strazzulla Tract	N/A
Pal Mar and Corbett Hydropattern Restoration	N/A
Acme Basin B Discharge	N/A

¹CP – Critical Project

Evaluation of economic effects of the alternatives was concerned with various aspects of the relationships between the economy and water. For example, water is necessary for agricultural and manufacturing processes, and individual survival. It is important for recreation and tourism. It is necessary for navigation. It plays a significant and obvious role in commercial and recreational fishing. The costs of transporting and treating water before and after its use, as well other costs associated with water use, are imbedded in the network of relationships and transactions of the economy. These interrelationships between the economic system and the ecosystem from which water is either consumed, or used in a non-consumptive way, by the economic system are the focal point for measuring some of the costs and benefits of the alternative plans.

The water-economy linkages briefly discussed above are perhaps the more obvious ones. There are also important linkages between the health of south Florida's natural ecosystem, and adequate amounts and timing of water, discussed elsewhere in this and other documents. The more elusive, hard-to-measure linkages, are those between the economic system and the natural ecosystem. This set of relationships is harder to see on a case-by-case basis (some polluted runoff here, some wildlife habitat lost there). In the aggregate, however, it is clear that a healthy functioning ecosystem is part of the requisite infrastructure for a healthy functioning economy. For purposes of this study, economic benefits were not used to "justify" ecosystem restoration plans.

The economic evaluation considered the effects on: agricultural water use, municipal and industrial water use, potential changes in flooding damages, navigation, recreation, and commercial fishing. A summary of the findings of this evaluation are displayed in *Table 7-17* and for a complete description of the evaluation, refer to *Appendix E*.

Agricultural Water Supply – Since all plans involve some change in the management of water, the potential exists for changes in the amount and timing of water available for irrigation of crops, as well as changes in the water table. Such changes could in turn affect agricultural productivity (different productivity for existing crops, different crops, changes in crop practices, etc.). For the Everglades Agricultural Area and the Lower East Coast, changes in water deliveries to agriculture were converted to changes in agricultural crop yields, and in turn, to changes in net farm income. The agricultural water supply effects in the St. Lucie and Caloosahatchee Basins were measured by estimating the difference between the amount of irrigation water provided for a particular alternative and the demands of that basin. The result is a "demands-not-met" measurement that was compared to the Without Plan Condition. This analysis revealed that the alternative plans should result in a positive effect.

Municipal and Industrial Water Supply – Projections of future water demand were made using the IWR-MAIN Water Demand Forecasting software, and were used as input to the South Florida Water Management Model. Changes in water deliveries to the urban users were converted to estimated willingness to pay values. There is expected to be a positive effect for each of the alternative plans compared to the Without Plan Condition.

TABLE 7-17
ECONOMIC EFFECTS OF THE ALTERNATIVE PLANS
 (\$Millions)

Economic Category	How Measured	Alternatives					
		Without Plan	A	B	C	D	D-13R
Agricultural Water Supply: Everglades Agricultural Area and Lower East Coast St Lucie Basin Caloosahatchee Basin	Average Annual value of unmet demands (lower is better)	\$2.6	\$.58	\$.88	\$.66	\$.74	\$.71
	Percentage of Demands Not Met (lower is better)	22.4%	4.1%	6.5%	4.1%	3.1%	3.1%
		31.6%	9.2%	14.9%	9.0%	7.5%	7.5%
Municipal and Industrial Water Supply	Average Annual Value of Unmet demand (lower is better)	\$31.8	\$10.2	\$10.3	\$6.4	\$4.6	\$4.6
Commercial Navigation	Percent of time Lake Okeechobee falls below critical stage (12 feet) (lower is better)	30%	16%	20%	16%	11%	11%
Recreation	See Appendix E	NQ	NQ	NQ	NQ	NQ	NQ
Commercial and Recreational Fishing	See Appendix E	NQ	NQ	NQ	NQ	NQ	NQ
Flood Control	See Appendix E	NQ	NQ	NQ	NQ	NQ	NQ
Regional Economic: Earnings Employment Output	Expressed as percent of regional economy (higher is better)						
		NA	.08%	.08%	.10%	.13%	.14%
		NA	.06%	.07%	.07%	.10%	.11%
		NA	.08%	.09%	.08%	.12%	.14%

NQ – effects were not quantified

% - percent

** Regional Economic effects for the alternatives are the difference between with and without a plan.

Commercial Navigation – Low lake levels affect the ability of commercial navigation traffic to safely navigate the Lake Okeechobee Waterway, and can also result in lock operation restrictions. Prior to this study, it was felt that changes in Lake Okeechobee water levels associated with some of the plans could impact navigation in Lake Okeechobee. However, for the alternative plans, this is not an issue. Lake level fluctuations appear to be moderated in the plans being considered compared to the Without Plan Condition. High levels are not as high as, and low levels are not as low as in the Without Plan Condition. The navigation effects could have been translated into monetary units, but the data uncertainty is such that the effects were evaluated by identifying when Lake Okeechobee stages fall below 12 feet.

Recreation – Recreation is a major industry in south Florida, and the natural ecosystems play a potentially important contributing role. Besides opportunities for ecosystem-related tourism (visitor centers, educational programs, etc.), there are potentially major implications for that part of the economy linked to the health of Florida Bay (mainly Monroe County, which includes the Florida Keys). While there is the possibility of a significant positive effect associated with any of the alternative plans being examined, but there is so much uncertainty at this stage of the planning process, that such effects were not monetized. *Appendix E* includes a

lengthy discussion about this topic and the context within which possible changes will take place. However, the kind of detailed information that is necessary to estimate recreation effects of the different alternative plan was not available during this study.

Commercial Fishing – It is possible that economic commercial and recreational fishing benefits could result from the alternative plans. If fish stocks were to increase as a result of positive Florida Bay responses to Everglades ecosystem restoration, and commercial fish catch were to increase, then the difference in the value of fish catch would be an economic benefit. Some studies reveal strong evidence suggesting that such could be the case, particularly for pink shrimp. The potential exists for similar positive effects in the other affected areas of St. Lucie Estuary, Caloosahatchee Estuary, and Biscayne Bay. These effects could extend to offshore fisheries as well, due to the relationship between conditions in the bays and estuaries, which provide nursery functions for the offshore fisheries. Again, details necessary to identify monetary effects of each alternative plan were not available during this study. Similar to the recreation analysis, a discussion of the role commercial fishing plays in the economy is provided in *Appendix E* to highlight the relative significance of potential impacts in this area.

Flood Damage Reduction – A major justification for much of the existing C&SF Project was to control flooding. Modifications to achieve ecosystem restoration have the potential to change flood control. For example, alternative plans that increase canal capacities or include additional water storage capacity enhance flood control provided by the system. For this study, neither additional benefits nor costs (increased damages) have been quantified. This was because the South Florida Water Management Model, which was the primary tool used to simulate the alternative plans, did not have the spatial resolution, nor was it sufficiently calibrated in the urban areas to definitively evaluate flood damage changes expected to result from any of the alternative plans. However, known (existing) problem areas were defined and cross-compared with some of the South Florida Water Management Model output that identifies gross changes in annual peak stage. Further, during the engineering design of the plan components, steps were taken to minimize potential flooding that could result from any of the components. Therefore, the flood damage reduction analysis, which can be found in *Appendix E*, identified areas which have a strong potential for follow-on flood damage reduction or mitigation analysis that may be needed in the more detailed implementation analyses which will follow the Restudy.

Regional Economic Development Effects – Regional economic impact effects were estimated for the alternative plans. This included the “multiplier” effects of project spending, as well as agricultural water supply changes, and the impact of agricultural land taken out of production due to project components (e.g., water storage facilities). In the context of the 12- county area of economic influence, the

alternative plans would result in a relatively small positive effect on the regional earnings, sales, and employment. The analysis, which can be found in *Appendix E*, showed that the positive effects associated with project spending and increased agricultural production due to fewer water restrictions would be greater than the negative effects of agricultural land removed from production for storage facilities.

7.5.2 Environmental Evaluation of the Alternative Plans

Two different methods were used to assess the ecological performance of the alternative plans. The color assessment scheme developed by the Alternative Evaluation Team was the first method of assessment. This provides information about the potential for achieving the long-term ecologic objectives. The team used "green" to indicate that an alternative plan will likely result in the recovery and long-term sustainability of the ecologic and water supply objectives in the sub-region. The goal was to achieve a green assessment for all areas throughout the study area indicating potential system-wide restoration.

This assessment was used to quantify the spatial extent in meeting the planning objective by summing the acreage of each sub-region that was assessed as green. The result of this evaluation is displayed as "Green Acres" in *Table 7-18*. Alternative D-13R resulted in a substantially larger area of predicted sustainable ecosystems than any of the other plans evaluated. Had all sub-regions achieved this goal, approximately 2.7 million acres would be restored to levels capable of sustaining long term ecological objectives. The without plan condition has no areas assessed green; therefore, 0 acres.

A second evaluation was conducted to determine the success of alternative plans in meeting the planning objective for improving habitat quality of natural areas in south Florida. Habitat quality is critical to reestablishing sustainable populations of fish and wildlife resources in the central and south Florida ecosystem. To measure this objective, "Habitat Units" were calculated by multiplying the area of a sub-region (acres) by the numeric output from the River of Grass Evaluation Methodology. When summed, the habitat units provide an indication of the potential system-wide habitat quality. The result of this evaluation is displayed in *Table 7-18*. If all sub-regions were restored, the result would be 2.7 million habitat units. Alternative D-13R resulted in 2.2 million habitat units, the most for any of the plans evaluated.

The Other Project Elements are not included within the domain of the South Florida Water Management Model; therefore, the environmental evaluations of these features were not included in the color assessment nor the River of Grass Evaluation Methodology. An estimate was prepared using principles similar to the River of Grass Methodology but at a more localized scale. The evaluation of the Other Project Elements included development of habitat units for the localized

benefits produced within the "footprint" of the feature. No attempt was made to assess benefits that were expected to accrue offsite or benefits from Other Project Elements without a discrete footprint, such as the Biological Control for Melaleuca and Other Invasive Exotic Species project. The construction of this feature would have system-wide benefits but the assumptions necessary to make an estimate of habitat unit improvement would be overly gross and were not attempted. Accordingly, the estimate of Other Project Elements benefits is considered underestimated at 9,000 habitat units.

7.5.3 Cost Effectiveness and Incremental Cost Analyses

Cost effectiveness and incremental cost analyses reveal information about good financial investments given the dollar costs and non-dollar outputs ("benefits") of alternative investment choices. The analyses are conducted in a series of steps that progressively identify alternatives that meet specified criteria and screen-out those that do not. Corps Engineer Regulation 1105-2-100 requires cost effectiveness and incremental cost analyses to support recommendations for ecosystem restoration.

Cost effectiveness analysis begins with a comparison of the costs and outputs of alternative plans to identify the least cost plan for every possible level of output. The resulting least cost alternative plans are then compared to identify those that will produce greater levels of output at the same cost, or at a lesser cost, as other alternative plans. Alternative plans identified through this comparison are the cost effective alternative plans. Next, the cost effective alternative plans are compared to identify the most economically efficient alternative plans, that is, the "best buy" alternative plans that will progressively produce the "biggest bang for the buck". Finally, the additional costs for the additional amounts of output ("incremental cost") produced by the best buy alternative plans are calculated. The results of all of the calculations and comparisons of costs and outputs provide a basis for addressing the decision question "Is it worth it?" In the case of the Restudy, the question is how much ecosystem restoration is worth the dollar cost? Additional information about the analyses is in *Evaluation of Environmental Investments Procedures Manual, Interim: Cost Effectiveness and Incremental Cost Analyses* by the U.S. Army Corps of Engineers, Institute for Water Resources (USACE, 1995).

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**TABLE 7-18
ENVIRONMENTAL EVALUATION
OF THE ALTERNATIVE PLANS**

Sub-Region	Acres	Existing		Without Plan		A		B		C		D		D-13R	
		ROGEM	HU	ROGEM	HU	ROGEM	HU	ROGEM	HU	ROGEM	HU	ROGEM	HU	ROGEM	HU
Lake Okeechobee	467,000	0.6	280,200	0.6	280,200	0.8	373,600	0.8	373,600	0.9	420,300	0.9	420,300	0.9	420,300
Caloosahatchee Estuary	9,000	0.0	0.0	0.1	900	1.0	9,000	1.0	9,000	1.0	9,000	1.0	9,000	1.0	9,000
St. Lucie Estuary	5,000	0.0	0.0	0.1	500	0.8	4,000	0.8	4,000	0.8	4,000	0.8	4,000	0.9	4,500
Loxahatchee NWR	143,000	1.0	143,000	0.6	85,800	1.0	143,000	1.0	143,000	1.0	143,000	1.0	143,000	1.0	143,000
WCA-2A	105,000	0.4	42,000	0.4	42,000	0.4	42,000	0.4	42,000	0.4	42,000	0.4	42,000	0.6	63,000
WCA-2B	28,000	0.1	2,800	0.1	2,800	0.1	2,800	0.1	2,800	0.1	2,800	0.1	2,800	0.1	2,800
Northwest WCA-3A	118,000	0.1	11,800	0.4	47,200	0.8	94,400	0.8	94,400	0.8	94,400	0.8	94,400	0.8	94,400
Holey Land and Rotenberger WMAs	61,000	0.4	24,400	0.6	36,600	0.8	48,800	0.8	48,800	0.8	48,800	0.8	48,800	0.8	48,800
Northeast WCA-3A	54,000	0.1	5,400	0.4	21,600	0.8	43,200	0.6	32,400	0.1	5,400	0.1	5,400	0.4	21,600
Eastern WCA-3A	74,000	0.1	7,400	0.4	29,600	0.1	7,400	0.1	7,400	0.1	7,400	0.1	7,400	0.4	29,600
Central and Southern WCA-3A	276,000	0.4	110,400	0.4	110,400	0.8	220,800	0.8	220,800	0.4	110,400	0.4	110,400	0.8	220,800
WCA-3B	69,000	0.8	55,200	0.4	27,600	1.0	69,000	0.1	6,900	0.1	6,900	0.1	6,900	0.6	41,400
Pennsuco	18,000	0.4	7,200	0.4	7,200	0.6	10,800	0.6	10,800	0.8	14,400	0.8	14,400	0.8	14,400
Shark River Slough	204,800	0.2	40,960	0.3	61,440	0.5	102,400	0.6	122,880	0.6	122,880	0.6	122,880	0.8	163,840
Rockland Marl Marsh	77,000	0.2	15,400	0.6	46,200	0.7	53,900	0.7	53,900	0.8	61,600	0.8	61,600	0.8	61,600
Model Lands	18,000	0.6	10,800	0.6	10,800	0.5	9,000	0.7	12,600	0.8	14,400	0.8	14,400	0.8	14,400
Florida Bay	448,000	0.2	89,600	0.3	134,400	0.8	358,400	0.9	403,200	0.8	358,400	0.8	358,400	0.8	358,400
Biscayne Bay	138,000	0.9	124,200	0.8	110,400	0.5	69,000	0.6	82,800	0.8	110,400	0.8	110,400	0.8	110,400
South & Southeast Big Cypress	364,000	0.9	327,600	0.9	327,600	1.0	364,000	0.9	327,600	1.0	364,000	1.0	364,000	1.0	364,000
Total Habitat Units			1,298,360		1,383,240		2,025,500		1,998,880		1,940,480		1,940,480		2,186,240
Green Acres (Sustainable Ecosystem)	2,712,800	NE		0		680,000		680,000		793,000		1,331,000		2,405,800	

NE-- Not Evaluated HU -- Habitat Unit

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In practice, Corps ecosystem restoration studies typically measure the ecosystem benefits of alternative plans in terms of physical dimensions (number of acres of wetlands, for example), or population counts (number of wading birds, for example), or various habitat-based scores ("habitat units" based on the U.S. Fish and Wildlife Service's *Habitat Evaluation Procedures*, or "HEP", for example). Any of these metrics may be used in conducting cost effectiveness and incremental cost analyses. For the purposes of the Restudy, the analyses were conducted using the "habitat unit" and "green acre (sustainable ecosystem)" measurements of plan outputs; see *Section 7.5.2 Environmental Evaluation of the Alternative Plans* and *Table 7-18* for additional information about these metrics. Recognizing the cautions and limitations on using these metrics in a comparative manner and the uncertainties inherent in the metrics as well as the cost estimates, the habitat unit and green acre estimates were used in the analyses to illustrate the type of information they may reveal.

Cost effectiveness and incremental cost analyses were conducted for Alternatives A, B, C, D and D-13R. The analyses compared the alternative plans' average annual costs (over a 20-year construction period) against the habitat unit and green acre estimates. In preparation for the analyses, the effects of each alternative were calculated by subtracting the Without Plan Condition value from the with-alternative value ("with-and-without analysis") to determine the value of the alternative's change. *Table 7-19* displays the resulting scores for the habitat unit and green acre outputs, as well as costs, used in the cost effectiveness and incremental cost analyses.

The results of the cost effectiveness and incremental cost analyses for the final Restudy alternative plans are summarized in *Table 7-20* and *Figure 7-7* and provide the following information about the plans:

- In comparing costs against habitat units, Alternatives B, C and D would not be good choices because each would produce fewer habitat units at a greater cost compared to Alternative A. Therefore, if Alternatives B, C and D are set aside based on this reason, the remaining cost effective plans would be Alternatives A and D-13R. A subsequent analysis to identify the "best buy" plans indicated that Alternative A is the first best buy plan (with an incremental cost per habitat unit of \$390), followed by Alternative D13R as the second and final best buy plan (with an incremental cost per habitat unit of \$930).
- In comparing costs against green acres, Alternative B would not be a good choice because it would produce the same number of acres but at a greater cost compared to Alternative A. Therefore, if Alternative B is set aside based on this reason, the remaining cost effective plans would be Alternatives A, C, D and D-13R. A subsequent analysis to identify the "best buy" plans

indicated that Alternative D-13R is the only best buy plan (with an incremental cost per green acre of \$170).

TABLE 7-19
COSTS AND OUTPUTS USED
IN COST EFFECTIVENESS AND INCREMENTAL COST ANALYSES
OF FINAL ALTERNATIVE PLANS

	Without Plan	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D-13r
Average Annual Cost (\$1,000)	\$0	\$253,540	\$286,305	\$340,937	\$382,831	\$402,292
Habitat Units	0	642,260	615,640	557,240	557,240	803,000
Green Acres	0	680,000	680,000	793,000	1,331,000	2,405,800

TABLE 7-20
RESULTS OF THE
COST EFFECTIVENESS AND INCREMENTAL COST ANALYSES
OF FINAL ALTERNATIVE PLANS

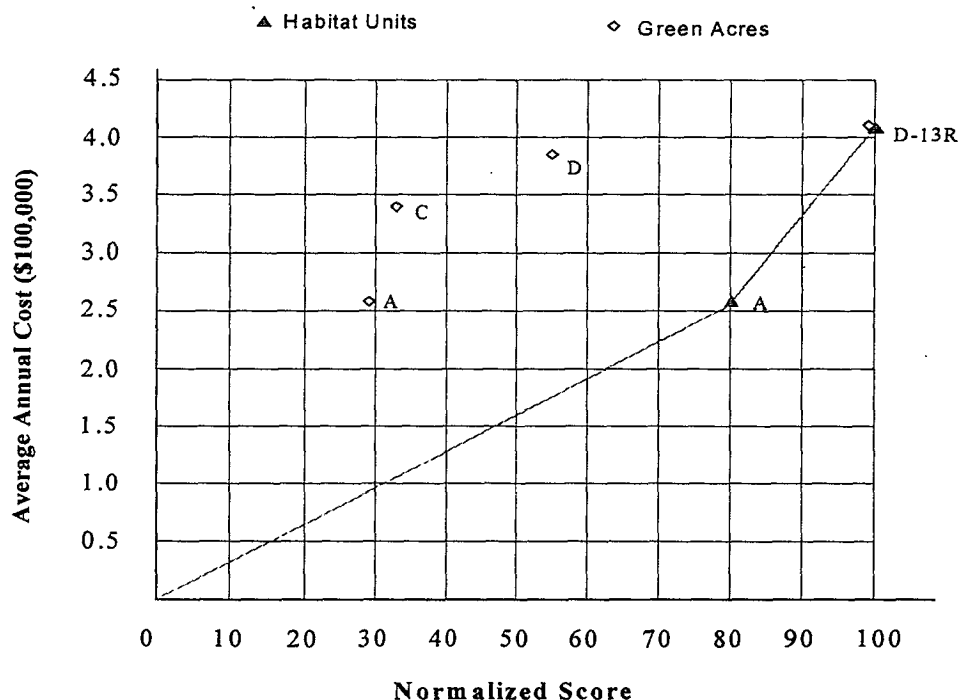
Output Indicators	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D-13r
Habitat Units	Cost effective and best buy plan				Cost effective and best buy plan
Green Acres	Cost effective plan		Cost effective plan	Cost effective plan	Cost effective and best buy plan

Table 7-21 presents the incremental cost information for the best buy alternative plans for both habitat units and green acres output indicators.

**TABLE 7-21
INCREMENTAL COST INFORMATION
FOR THE BEST BUY ALTERNATIVE PLANS**

HABITAT UNITS						
Best Buy Alternative plans	Average Annual Cost (\$1,000)	Habitat Units	Additional Average Annual Cost	Additional Habitat Units	Incremental Cost per Habitat Unit	Average Cost per Habitat Unit
Without Plan Condition (No Action)	\$ 0	0	\$ 0	0	Not applicable	Not Applicable
Alternative A	\$253,540	642,260	\$253,540	642,260	\$0.39	\$0.39
Alternative D-13R	\$402,292	803,000	\$148,752	160,740	\$0.93	\$0.50
GREEN ACRES						
Best Buy Alternative plans	Average Annual Cost (\$1,000)	Green Acres	Additional Average Annual Cost	Additional Green Acres	Incremental Cost per Green Acre	Average Cost per Green Acre
Without Plan Condition (No Action)	\$ 0	0	\$ 0	0	Not applicable	Not applicable
Alternative D-13R	\$402,292	2,405,800	\$402,292	2,405,800	\$0.17	\$0.17

**FIGURE 7-7
COST EFFECTIVE ALTERNATIVE PLANS**



7.5.4 Fish and Wildlife Mitigation Analysis

Some of the components in the alternative plans have the potential to cause localized adverse environmental impacts. For example, the construction of levees, canals, reservoirs and stormwater treatment areas, could adversely impact wetlands and other aquatic sites as well as native upland habitats. The locations of many features are known, while others are only conceptually proposed within a study region or basin. As site-specific details for the components are developed during the Project Implementation Process, land suitability analyses will be utilized as part of the site selection process. Sites with extensive wetland and/or aquatic habitats and native upland habitats will be avoided to the greatest extent practicable. For selected sites where impacts to these habitats are unavoidable, impacts will be minimized through project design. Notwithstanding the current uncertainty regarding component siting and design, an analysis was conducted to determine the approximate extent of these potential impacts.

For the features that involve large areal extent like reservoirs, estimates were made for the affected wetland acreage. For the known sites, the acreage estimates were based on available information, such as existing studies, aerial

photography and other physiographic data. Due to the variety of native upland habitats that could be encountered and the inability to discern them at the level this estimate was made, potential impacts to uplands were not included in this analysis. Furthermore, it is anticipated that the land suitability analyses to be utilized during the Project Implementation Report processes will minimize the potential effects on native habitat types in favor of disturbed sites. For sites that were only conceptually located, conservative estimates were made of the percent of wetland area expected to be encountered. For linear features such as canals and levees, the worst case scenario was used and it was assumed these features would be located entirely within wetlands.

In addition to the estimates of wetland acreage that could be affected, habitat quality estimates were made for both the existing and with-plan conditions. These wetland habitat quality estimates were made using a scale of zero to one, with 0.0 representing very poor habitat quality and 1.0 representing optimum habitat quality. For the existing condition estimates, habitat quality was based on available data for project features with known locations and best professional judgement was used for project features with conceptual locations. To estimate the habitat quality for the with-plan condition, operational details of the feature are needed. For example, the hydrologic operation and vegetative management of the Water Preserve Areas will dictate the effect on habitat quality as either beneficial or detrimental. Again, a conservative approach was taken and all features were assumed to produce an adverse impact. The total estimate of the potential adverse impacts of Alternative D-13R and the Other Project Elements is a loss of approximately 10,000 "wetland habitat units". These units were derived by multiplying the estimated area of affected wetlands by the difference between the existing and with-plan habitat quality estimates.

7.5.5 Uncertainty Analysis

The primary purpose of the uncertainty analysis (see *Appendix O*) was to identify which of the remaining uncertainties are most significant. That is, which have the most potential to affect the effectiveness of the project that will eventually be implemented. A secondary purpose of the analysis was to identify broad strategies that can be used to address or reduce the remaining uncertainties.

Much of the uncertainty that attends this study effort is considered routine uncertainty. Planning is an iterative process. The iterations are distinguished by an increasing quantity and quality of information and a corresponding decrease in uncertainty. In any planning study there are things that are unknown at one point in time that must and will be known before the project can be implemented. That includes such things as specifically where project elements will be located, how much they will cost, and who will pay for them, among many other issues. While there is a great deal of routine uncertainty attending the current iteration of this

planning study, processes have been developed to ensure that they are resolved in due time.

Although much of the uncertainty that remains in the Restudy is routine and will be addressed in time, there are some uncertainties that are too unique to ignore. For example, although the basic workings of Aquifer Storage and Recovery (ASR) technology are a perceived uncertainty, there are some unique uncertainties associated with their application on a magnitude of this scale. Four key uncertainties were identified in the analysis that are unique enough to warrant special attention in the future. They include:

- Uncertainties about major Restudy models;
- Uncertainties about the linkage between hydrologic change and ecosystem restoration;
- Uncertainties about new technologies; and,
- Uncertainties about the risks associated with the Comprehensive Plan.

Appendix O includes the commitments that the Restudy Team has made to address these key uncertainty issues in subsequent planning and design activities and recommendations for additional studies to help resolve outstanding uncertainty issues including a qualitative risk assessment.

7.5.6 Planning Criteria

Performance of the alternative plans with respect to the planning objectives including ecologic, economic, and hydrologic criteria, is displayed in *Table 7-22*.

7.5.7 Evaluation Accounts

Planning by Federal agencies for water resource development and management is guided by the requirements of the U.S. Water Resources Council's Principles and Guidelines. The Principles and Guidelines establish the Federal Objective for water projects, set forth a six-step planning and decision making process, and prescribe four accounts of evaluation.

**TABLE 7-22
PLANNING CRITERIA EVALUATION**

PLANNING CRITERIA	WITHOUT PLAN	A	B	C	D	D-13 R and OPEs
ECOLOGIC Increase the total spatial extent of natural areas (Acres of Sustainable Ecosystem, Green ranking)	0 acres	680,000 acres	680,000 acres	793,000 acres	1,295,000 acres	2,370,000 acres
Improve habitat and functional quality (ROGEM Numeric Score x effected acres) HU = Habitat Units	1,383,000 HU	2,025,000 HU	1,000,000 HU	1,940,000 HU	1,940,000 HU	2,186,000 HU
Improve native plant and animal species abundance and diversity (Number of Ecologic Landscape Types that are Sustainable, Green Ranking)	NA	58	58	58	56	58
ECONOMIC Increase availability of fresh water (volume of water restriction cutback for agricultural / urban, Acre-feet)	6,665,000	1,798,000	2,325,000	1,767,000	1,395,000	1,333,000
Reduce flood damages	Evaluation did not result in quantification of benefits and impacts since SFVMM is not designed for flood studies. Refer to Appendix E for description of the analysis.					
Provide recreational and navigation opportunities: Lake Okeechobee (percent time Lake Okeechobee falls below 12 feet)	30%	16%	20%	16%	11%	11%
Other recreational opportunities	Problematic to quantify effects of alternative plans; current expenditures \$404 million (parks and preserves), \$598 million (region); current consumer surplus \$290 million (parks and preserves), \$764 million (region)					
HYDROLOGIC Regain lost storage capacity (Additional Storage – total for 31 year period of record) (Coastal Discharges – water wasted to tide)	NA 1,774,000 ac-ft	44,016,000 ac-ft 67,000 ac-ft	48,315,000 ac-ft 138,000 ac-ft	48,369,000 ac-ft 383,000 ac-ft	52,469,000 ac-ft 311,000 ac-ft	52,005,000 ac-ft 311,000 ac-ft
Restore more natural hydropatterns (acres with improved ROGEM scores)	NA	2,725,358	2,656,188	2,344,142	1,669,263	2,777,045
Improve timing and quantities of fresh water deliveries to estuaries (Flood Discharge Volumes from Lake Okeechobee)	9,114,000 ac-ft	1,116,000 ac-ft	682,000 ac-ft	868,000 ac-ft	930,000 ac-ft	868,000 ac-ft
Restore water quality conditions (Cumulative Score from combined ranking matrix, higher = better)	27.0	32.5	35.5	30.5	40.5	45.5

The four accounts facilitate the evaluation, display, and comparison of the effects of alternative plans. These accounts are national economic development (NED), environmental quality (EQ), regional economic development (RED) and other social effects (OSE). The EQ account shows effects on ecological, cultural, and aesthetic attributes of significant natural and cultural resources that cannot be measured in monetary terms. The OSE account shows urban and community impacts and effects on life, health and safety. The NED account shows effects on the national economy. The RED account shows the regional incidence of NED effects, income transfers, and employment effects.

These four accounts encompass all significant effects of plan implementation, including economic, socioeconomic and environmental effects that must be considered in water resources planning as prescribed in the following Federal laws:

- The 1969 National Environmental Policy Act (Public Law 91-190);
- Section 122 of the 1970 Rivers and Harbors Act (Public Law 91-611);
- Sections 904 and 905 of the 1986 Water Resources Development Act (Public Law 99-662).

The 1969 National Environmental Policy Act (NEPA). Public Law 91-190 (42 USC 4321) requires assessment of alternative plan impacts on the human environment. NEPA also requires documentation of the planning process, alternative plan comparison and plan selection.

Section 122 of the Rivers and Harbors Act of 1970 (Public Law 91-611, 84 STAT. 1823) requires that consideration be given to possible adverse economic, social and environmental effects. It also requires that final decisions on the project be made in the best overall public interest, taking into consideration the need for flood control, navigation and associated purposes; and the associated costs of eliminating or minimizing the following adverse affects:

- Air, water and noise pollution;
- Destruction or disruption of man-made and natural resources, esthetic values, community cohesion, and availability of public facilities and services;
- Adverse employment effects;
- Tax and property value losses;
- Injurious displacement of people, businesses and farms;
- Disruption of desirable community and regional growth.

Section 904 of the 1986 Water Resources Development Act (Public Law 99-662, 100 STAT. 4185, 33 USC 2281) describes additional requirements that must be addressed in the formulation and evaluation process for Federal water resources

projects. These requirements are listed below. The formulation and evaluation process must consider the associated benefits and costs of these items, both quantifiable and unquantifiable, and must be displayed in the benefits and costs of such projects.

- Enhancing national economic development;
- Quality of the total environment;
- The well-being of the people;
- Prevention of loss of life;
- Preservation of cultural and historical values.

Section 905 of the 1986 Water Resources Development Act (Public Law 99-662 (100 STAT. 4185, 33 USC 2282) describes the requirements for feasibility reports for any water resources project or related study authorized to be undertaken by the Secretary. The feasibility report will describe, with reasonable certainty, the economic, environmental and social benefits and detriments of the recommended plan and alternative plans considered by the Secretary.

Effects of the alternative plans in the four evaluation accounts are displayed in *Tables 7-23* and *Table 7-24*.

TABLE 7-23
EVALUATION ACCOUNTS LISTED IN THE
"PRINCIPLES AND GUIDELINES"
(all dollar values in \$ millions)

Evaluation Accounts	WITH- AND WITHOUT-PROJECT CONDITIONS					
	2050 Base Condition	Alternative A	Alternative B	Alternative C	Alternative D	Recommended Plan
National Economic Development Account						
Agricultural Water Supply:		\$0.6	\$0.9	\$0.7	\$0.8	\$0.7
Avg. annual value of unmet demand*	\$2.6	(+\$2.0)	(+\$1.7)	(+\$1.9)	(+\$1.8)	(+\$1.9)
M&I Water Supply:	\$31.8	\$10.2	\$10.3	\$6.4	\$4.6	\$4.6
Avg. annual value of unmet demand*		(+\$21.7)	(+\$21.5)	(+\$25.4)	(+\$27.2)	(+\$27.2)
Flood Control	• Limited evaluation of impacts, since SFWMM not designed for flood studies.					
Commercial Navigation	• No significant difference expected between with- and without-project conditions.					
Recreation	• Problematic to quantify effects of alternative plans. • Current Expenditures: \$404 million (parks/preserves); \$598 million (region). • Current Consumer Surplus: \$290 million (parks/preserves); \$764 million (region).					
Commercial/Recreational Fishing	• Annual revenues estimated for commercial and guided & recreational sportfishing in five areas: Lake Okeechobee, St. Lucie & Caloosahatchee estuaries, and Biscayne & Florida bays. • Significant positive economic impacts are expected to result from hydrologic modifications and consequent ecological impacts to all five areas with the exception of Biscayne Bay.					
Project Costs						
Total Construction & Real Estate Costs		\$5,229	\$6,023	\$6,725	\$7,335	\$7,789
Annual Operations & Maintenance Costs		\$70	\$72	\$126	\$162	\$165
Annual Monitoring Costs		\$10	\$10	\$10	\$10	\$10
Annualized Costs		\$254	\$286	\$341	\$383	\$402
Regional Economic Development Account						
Average annual effects (% of regional economy)						
Output		\$173 (.08%)	\$195 (.09%)	\$192 (.09%)	\$277 (.12%)	\$307 (.14%)
Employment (jobs)		1,707 (.06%)	1,934 (.07%)	2,057 (.07%)	2,903 (.10%)	3,165 (.11%)
Earnings		\$59 (.08%)	\$65 (.08%)	\$78 (.10%)	\$103 (.13%)	\$108 (.14%)
Environmental Quality Account	• Refer to Table 7-22 and 7-24 for a display of ecologic, cultural, and aesthetics attributes.					
Other Social Effects Account	• Potential community disruption from conversion of agricultural land to reservoirs.					

Note, A "+" indicates a reduction in unmet water demand.

**TABLE 7-24
SUMMARY OF EFFECTS**

CATEGORIES OF EFFECTS	EXISTING CONDITION	WITHOUT PLAN	A	B	C	D	Selected Plan
Air Quality	H	H	0	0	0	0	0
Noise Pollution	L	L	_-**	_-**	_-**	_-**	_-**
Water Quality	L-M	M	_-**/+	_-**/+	_-**/+	_-*/+	_-**/+
Natural Resources	M	M	+/+	+/+	+/+	+/+	+/+
Wetlands	M	L	+	+	+	+	++
Endangered and Threatened Species	4 Critical Habitats	0	+	+	+	++	++
Fish and Wildlife	M	L	+	+	+	++	++
Wild and Scenic Rivers	8 miles	8 miles	+	+	+	+	+
Coastal Zone	--	--	+	+	+	+	++
Flood Plains	M	M	0	0	0	0	0
Aesthetic Values	M	M	0	0	0	0	0
Man-made Resources	M	M	+/-	+/-	+/-	+/-	+/-
Community Cohesion	M	M	N/A	N/A	N/A	N/A	N/A
Historic and Cultural Properties	L	L	0	0	0	0	0
Public Facilities and Services	M	M	+	+	+	+	+
Employment	M	M	+	+	+	+	+
Tax Values	M	M	+	+	+	+	+
Property Values	M	M	+	+	+	+	+
Displacement of People	L-M	L-M	-	-	-	-	-
Displacement of Businesses	L-M	M-H	-	-	-	-	-
Prime and Unique Farmlands	L	M	_-***	_-***	_-***	_-***	_-***
Displacement of Farms	M	M-H	--	--	--	--	--
Desirable Community Growth	M	M	+	+	+	+	+
Desirable Regional Growth	M	M	+	+	+	+	+

Existing and Without Plan Conditions display estimates of each resources relative values: H = high, M = moderate, L = low.

Plans' effects are estimates of net overall changes from the Without Plan Condition:

++ = very beneficial change

- = adverse change

+ = beneficial change

-- = very adverse change

0 = no change

N/A = not applicable

** During construction, localized

*** Unique Farmland will be taken out of production however no Prime Farmland will be impacted

7.6 PLAN FORMULATION PROCESS SUMMARY

The planning process used by the Restudy Team evolved over three years, ultimately resulting in selection of a recommended Comprehensive Plan. The team used an iterative decision making process to identify and evaluate the merits of individual components and the effects of combining these components into different comprehensive plans. The Restudy's major iterations are illustrated in Figure 7.1. Table 7-25 highlights the purpose, decision criteria and results of the major iterations.

TABLE 7-25
PLAN FORMULATION MAJOR ITERATIONS

ITERATION We started with:	PURPOSE Our intent was to:	CRITERIA We made decisions based on:	RESULT The iteration ended with:
Goals and Objectives	Progressively identify components to meet the goals and objectives	Ideas from technical experts and the public	Components
Components	Comparatively array and screen components	<ul style="list-style-type: none"> • Lower East Coast Regional Water Supply Plan • Water Preserve Areas Land Suitability Analysis • Everglades Screening Model • Cost Effectiveness Analysis 	Starting Point Alternative
Starting Point Alternative	Progressively formulate plans	Performance measures	Alternatives 1-6, which were screened to Alternatives A-D (3-6)
Alternatives A-D	Comparatively array and screen plans	<ul style="list-style-type: none"> • River of Grass Evaluation Methodology • Ranking Score • Grade Score • Color Score • Keystone and Endangered Species Evaluation • Water Quality 	Alternative D
Alternative D	Progressively reformulate plans	Performance measures	Alternative D-13R
Alternatives A-D and D-13R (Final array)	Comparatively array and screen plans	<ul style="list-style-type: none"> • Economic Evaluation • Environmental Evaluation • Cost Effectiveness and Incremental Cost Analyses • Mitigation Analysis • Planning Criteria • Evaluation Accounts 	D-13R plus Other Project Elements

As the Restudy planning iterations evolved, the criteria that were the basis for deciding the fate of solutions were refined and modified, but the planning objectives remained the same throughout. During the early iteration of screening components, it was possible to make such decisions using more qualitative information that was readily available from a limited number of analyses. This is in stark contrast to the final iteration in which new and more quantitative analyses were required to make more sophisticated judgments across a more extensive set of criteria. During each iteration, the decision criteria reflected the best available information that could be used to support decisions for dropping or retaining the solutions at hand.

This iterative planning process progressively eliminated inferior plans and carried superior plans forward for reformulation into even better plans. Subsequent iterations to improve the plans were based on criteria (and their related metrics) that had been refined and improved from criteria used in the previous iterations. Each iteration flowed from and built upon the decisions reached in the previous iterations. As such, the team did not carry along plans eliminated in previous iterations so that all plans are continually evaluated on an ever-evolving comparable basis. An iteration was not an opportunity to revisit previous decisions (although, on occasion, some iterations were indeed just that). Rather, each iteration sought to move decision making closer to a final recommendation.

7.7 SUBSEQUENT ITERATIONS OF THE RECOMMENDED PLAN

The U. S Department of Interior, and the Florida Game and Fresh Water Fish Commission listed a number of concerns about the draft Comprehensive Plan in the draft Fish and Wildlife Coordination Act Reports presented to the Corps of Engineers in August, 1998 (see *Annex A*). Some of these issues were considered critical to acceptance of the Comprehensive Plan. While it was considered unreasonable to expect these issues could be completely resolved before completion of this report, the South Florida Ecosystem Restoration Working Group agreed they warranted additional attention and additional modeling, if possible.

The Alternative Evaluation Team agreed to develop a short-term issue identification and resolution process for addressing the outstanding issues associated with the Comprehensive Plan. Task teams were formed. The Everglades Basin task team combined the former Total Systems, Northern and Central Everglades, Southern Everglades and Florida Bay, and Big Cypress subteams. The Southeastern Estuaries task team combined the Biscayne Bay and Model Lands/C-111 Basin subteams. The Water Quality subteam was already in existence and a small Northern Estuaries team was formed.

The four teams identified all outstanding issues including, but not limited to, those coming from the two Coordination Act Reports. Some of the issues were plan formulation, evaluation, and modeling issues occurring in each Alternative Evaluation Team sub-region. These issues were considered to be within the scope of the Alternative Evaluation Team. Other agency concerns, such as policy issues, were listed, but because they were beyond the scope of the Alternative Evaluation Team, they were not pursued further during this process. The issue teams then agreed that six issues were exceptionally important and deserved additional attention prior to completion of the final report.

Team members drafted issue papers on each of the five most important issues following an agreed-upon outline developed by the Everglades Basin team and ratified by the others. The purpose of each issue paper was to better define the issues, propose a process for resolving the issue by creating a common understanding of the specific tasks that will be required and the information needed to resolve each issue either for the final report or during the future planning and implementation of the recommended Comprehensive Plan. Each paper was to propose a time line for reaching closure on each issue.

The six issues can be paraphrased as follows:

1. The plan needs to increase total overland flow to Florida Bay, Northeast Shark River Slough and Taylor Slough to fully meet Natural System Model depth and duration targets.
2. The plan needs to improve ecological performance in the Water Conservation Areas by eliminating damaging high and low water conditions.
3. The plan should improve ecological conditions in Biscayne Bay by restoring more natural freshwater inflows.
4. The risks and uncertainties associated with using wastewater reuse as a water source for Biscayne Bay should be closely examined.
5. Restoration targets in the St. Lucie Estuary should be more closely met.
6. The plan needs to improve ecological performance in the Model Lands and C-111 Basins by providing adequate freshwater to maintain target hydropatterns.

The Alternative Evaluation Team also undertook to draft a white paper to refine the team's working definition of restoration.

The Alternative Evaluation Team and its issue resolution task teams had an array of both short-term and long-term opportunities for addressing the remaining issues. Possible avenues included: optimization modeling, model refinements, technical peer review for questions of science, additional field studies and measures, refinement and creation of new performance measures, the development of review papers (white papers) on key issues, recommending operational and structural improvements during the detailed design phases, the use of an adaptive assessment strategy, and the design of a comprehensive ecological monitoring program.

The short-term strategy outlined above was an interim strategy intended to feed into and support the implementation and adaptive assessment strategies currently being developed for this report and to satisfy the recommendations of the U.S. Fish and Wildlife Service and the Florida Game and Fresh Water Fish Commission Final Coordination Act Reports.

Four papers have been completed, reviewed by the Alternative Evaluation Team and accepted: the St. Lucie issue paper, the two Biscayne Bay issue papers, and the "defining restoration" white paper. The two Everglades basin teams combined and completed a draft issue paper. The issue papers can be found in the U.S. Fish and Wildlife Coordination Act Report (*Annex A*).

Understanding that two of the issues (numbers 1 and 3) would be resolved if the plan provided more water for Biscayne Bay and Shark River Slough, an initiative was begun to investigate the capture of additional water discharged to tide beyond the quantity captured in Alternative D-13R. This investigation included additional model runs of the SFWMM hydrologic model. These model runs were referred to as D-13R_x scenarios, with the _x representing each of the additional scenarios. For example, the first scenario developed was called D-13R₁. The purpose of these scenarios was to increase the water supply to Northeast Shark River Slough and Biscayne Bay by capturing and directing water currently discharged to tide in previous alternative plans. An intense effort by the interagency Alternative Evaluation Team subteam chairs and hydrologic modelers involved daily meetings to view model outputs, evaluate them, and quickly suggest improvements for model runs to be made that night for review the following day. A total of four scenarios were developed during this process with scenario D-13R₄ producing the greatest additional water flow. Therefore, only alternative D-13R₄ is described further in this report. The description of the other scenarios can be found on the Restudy web site (www.restudy.org).

7.7.1 Scenario D-13R₄ Description

The components of D-13R₄ scenario were designed to provide peak flood attenuation, reduction of freshwater discharges to tide and increase flows to Northeast Shark River Slough, Water Conservation Area 2A and Biscayne Bay

while recharging Miami-Dade County's coastal canals. This was accomplished by backpumping excess runoff from the C-51 Canal through the Lake Worth Drainage District's canal system (which will require conveyance improvements) and pumped into the Palm Beach County Agricultural Reserve Reservoir. From the Agricultural Reserve Reservoir, runoff will be discharged south into the Lake Worth Drainage District E-1W canal and routed into the Site 1 Impoundment. Further, the Site 1 Impoundment (Component M) had to be modified to accept the runoff routed south from the C-51 Canal. In addition, more runoff from the Hillsboro Canal was captured by increasing the inflow pump capacity. The Site 1 reservoir would be modified from the D13-R design (6 feet deep, 2,460-acre reservoir) to a 12 feet deep 300-acre reservoir and a 2,160-acre stormwater treatment area. This component modification also assumes that urban runoff that is pumped into the 300-acre reservoir provides recharge for the 30-5 MGD ASR wells proposed in D-13R. Further, water from the reservoir will gravity flow to the stormwater treatment area for treatment prior to discharging into the northeast corner of Water Conservation Area 2A. It is assumed that flood protection in all affected areas will be maintained.

Further, urban runoff from the C-14, C-13, North New River Canals and Water Conservation Area 2B levee seepage will be backpumped to the US 27 west borrow canal via C-42 and North New River Canals. This runoff will be directed south to the North Lake Belt Storage Area if storage is available in that facility. Discharges from the North Lake Belt Storage Area are described in Component XX. If storage is not available in North Lake Belt Storage Area, the backpumped water will be routed either to the Bird Drive Recharge Area or Biscayne Bay via the US 27 west borrow canal, the North Lake Belt Storage Area conveyance system improvements, and the C-1, C-2, C-4 and C-6 Canals. Deliveries will not be made during storm peaks to avoid impacting flood protection. If storage is not available in North Lake Belt Storage Area and conveyance capacities are also not available (without impact to flood protection), backpumping will not occur. Water quality of deliveries to Northeast Shark River Slough must be of acceptable quality for restoration or water will not be delivered. Additional types of water quality treatment may be required and it is assumed that flood protection in all affected areas will be maintained. Backpumping will not occur if the conveyance systems can not adequately pass flows to storage and/or treatment areas.

Finally, while the Everglades Construction Project is designed to backpump runoff from urban areas to the Water Conservation Areas after treatment within Stormwater Treatment Areas, this scenario denotes the first time the Restudy included a proposal to direct urban runoff into the Everglades Protection Area. These scenarios propose to direct water from C-51 into Water Conservation Area 2A after treatment and from North Lake Belt Storage Area, which receives runoff from C-6, C-9, C-11 and in this scenario C-14, C-13 and North New River to Northeast Shark River Slough after treatment. There are concerns about the level and practicality of treatment needed to provide water of appropriate quality to the

Everglades. Without completion of a pilot project, the quality of the water coming out of in-ground storage areas remains an unknown.

7.7.2 Evaluation of D-13R₄

The Alternative Evaluation Team conducted a preliminary evaluation of the D-13R₁₋₄ scenarios during a meeting of the full Alternative Evaluation Team on 20 January 1999. The objective of these additional scenarios was to determine the feasibility of improving D-13R, by capturing additional surplus water from the amount discharged to tide each year, and conveying that "new" water (plus redistributing excessive water in the Water Conservation Areas) to better meet performance targets in the natural system. These scenarios were designed to convey urban runoff water into the natural system, an alternative water management scheme that had not been included in any previous comprehensive plan alternative due to the high cost and the risk associated with contamination of the Everglades from urban runoff. The D-13R₄ scenario was clearly the most successful of the four scenarios that were developed during this intensive, multi-agency planning and modeling process, which began in November 1998.

The Alternative Evaluation Team found that the overall performance of Scenario D-13R₄, as modeled included both gains and losses when measured against the existing and the future without plan conditions, and D-13R. D-13R₄ captured an average of 245,000 acre-feet/year of new water for the natural system from Palm Beach and Broward counties. This new water, when combined with excessive water from the Water Conservation Areas, provided an average of 271,000 acre-feet of new water each year to Everglades National Park and an average of 77,000 acre feet of new water to Biscayne Bay each year. The increased annual mean flows to the park and Biscayne Bay are expected to produce substantial improvements towards meeting the hydrological performance targets for these two areas. Although D-13R₄ also provided modest improvements in northeast Water Conservation Area 3A and northeast 2B, by reducing the number of undesirable high water events in these two subregions, this scenario increased the number of undesirable high water events in Water Conservation Areas 2A and 3B to a level greater than that predicted for the two base conditions and D-13R. Further, D-13R₄ created undesirable increases in the depth and duration of flooding in the Pennsuco wetlands. By delivering urban water to the natural system, this scenario raises a number of new water quality questions.

The Alternative Evaluation Team recognizes that much new information regarding the potential performance of D-13R was gained during the modeling of the four scenarios. The hydrological responses during the modeling of these four scenarios convincingly demonstrated the operational flexibility of D-13R, and offers encouraging documentation that additional improvements can be achieved during the detailed planning phases of the restoration program. The Alternative Evaluation Team recommended that the specific features of D-13R₄ that allowed for

the capture and conveyance of substantial amounts of new water for the natural system be incorporated into the Recommended Plan, D-13R, contingent upon:

- (1) Finding a way to reduce the number of damaging high water events in Water Conservation Area 2A and 3B and the Pennsuco Wetlands to a level at or below the level predicted for D-13R.
- (2) Adequately treating the stormwater runoff from the C-51 east and C-13/14 basins directed into the Everglades Protection Area to meet all state and federal water quality standards to enable ecological restoration to be achieved.

It was agreed that these concerns can best be resolved during the finer scale modeling and planning, which will occur as a part of detail design work. The addition of these features should allow greater operational flexibility during future efforts to improve the overall performance of D-13R. Further, an issue paper is required from the Restudy's Water Quality Team, to more fully explore the questions being raised by the use of urban water to meet natural system targets in the Everglades.

Following the Alternative Evaluation Team's evaluation of D-13R₁₋₄, comments were received from Lake Worth Drainage District concerning the possible detrimental affects on flood protection that could be experienced within their system if the proposed modifications to their secondary canals are made. Lake Worth Drainage District recommended that the specific features of D-13R₄ not be incorporated into the recommended Comprehensive Plan until it can be demonstrated that the existing level of flood protection will not be compromised.

Finally, it should be noted that the Natural System Model topography in Northeast Shark River Slough is assumed to be the same as current topography, although recent data collected by the U.S. Environmental Protection Agency scientists indicate that substantial soil subsidence has occurred since the 1940's. This discrepancy in the topographic data in the model very likely affects the depth targets for Northeast Shark River Slough. Hence, if consistent topographic data assumptions were used for both Northeast Shark River Slough and Water Conservation Area 3B, target depths in Northeast Shark River Slough would be shallower, excess depths in Water Conservation Area 3B reduced and less water would be needed to meet Northeast Shark River Slough performance measure targets.

7.8 PLAN FORMULATION CONCLUSIONS

The initial screening effort identified the pressing need to capture more water in south Florida to restore the Everglades, protect the estuaries, and to provide for adequate water supply for urban and agriculture needs in the future. During the screening phase, the Restudy Team used modeling combined with an economic "best buy" approach to reduce to a workable number the vast array of components available for capturing and storing water and for conveying that water to the right parts of the system at the right time. Detailed plan formulation followed. In a nine-month period, representatives from every concerned agency - federal, state and local - worked closely together with other stakeholders to decide which features would be included in each alternative plan. Each alternative plan was modeled, the results reviewed by the team, and new alternative plans were formulated based on the improvements the team believed were needed. After looking at 10 alternative plans and over 25 modeling scenarios including D-13R₄, Alternative D-13R is by far the best of the alternative plans. This alternative, coupled with the 21 Other Project Elements, contains the array of components that has the most potential to achieve the Restudy's planning goals and objectives. Implementation of this plan will make restoration of healthy, sustainable south Florida ecosystems possible. Hence, Alternative D-13R, in combination with the Other Project Elements makes up the recommended Comprehensive Plan.

Economic and environmental evaluations of the plan show that the recommended plan is strongly justified. The environmental benefits are great and despite the scale of the project, it is extremely cost effective. The recommended plan appears to do what the varied participants in the study asked for it to do. More water has been captured and conveyed to areas where it is needed. Extreme events like regulatory releases to the estuaries, excessive flooding in the Water Conservation Areas and severe damaging dryouts in the marshes will be significantly reduced. Urban and agriculture areas will benefit from the extra water storage and be less dependent on the natural areas to meet their needs. Substantially more water makes its way into the large sloughs of Everglades National Park and the seasonal timing of flows throughout Everglades is more natural. In short, by balancing the needs of the natural system with the needs of urban areas and agriculture, a plan was developed which results in considerable benefits throughout the system. South Florida has clearly outgrown its old water management infrastructure and this plan provides sustainable solutions.

In response to comments made by the public and in the draft Fish and Wildlife Coordination Act reports the Alternative Evaluation Team produced a series of issue papers and developed additional modeling scenarios from D-13R. A major impetus for developing these scenarios was to determine if additional water could be captured in the Lower East Coast urban areas and used to better meet

performance measure targets in the Water Conservation Areas and Everglades National Park as well as for investigating alternative sources of water for Biscayne Bay. Preliminary evaluation by the Alternative Evaluation Team of scenarios D13R₁₋₄ indicate that additional captured water helps to meet hydrologic targets for Everglades National Park, Biscayne Bay and some areas within the Water Conservation Areas. However, in other areas of the Water Conservation Areas and the Pennsuco Wetlands, performance declines markedly relative to D-13R. In addition, issues relative to treating urban runoff prior to discharge into the Water Conservation Areas and the Everglades, and potential flooding impacts to secondary canals have not been resolved. These remaining areas of concern and the ultimate amount of additional water recaptured and its distribution will be determined in the subsequent more detailed design phase of individual components.

In summary, the recommended Comprehensive Plan contains the array of components that has the most potential to achieve the Restudy's planning goals and objectives. The subsequent detailed design phase of individual components will address the outstanding performance issues associated with the recommended Comprehensive Plan including:

1. The plan needs to increase total overland flow to Florida Bay, northeast Shark River Slough and Taylor Slough to fully meet Natural System Model depth and duration targets.
2. The plan needs to improve ecological performance in the Water Conservation Areas by eliminating damaging high and low water conditions.
3. The plan should improve ecological conditions in Biscayne Bay by restoring more natural freshwater inflows.
4. The risks and uncertainties associated with using wastewater reuse as a water source for Biscayne Bay should be closely examined.
5. Restoration targets in the St. Lucie Estuary should be more closely met.
6. The plan needs to improve ecological performance in the Model Lands and C-111 Basins by providing adequate freshwater to maintain target hydropatterns.